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NASA-CR-167428

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2. NASA/BLM APPLICATIONS PILOT TEST (APT)

PHASE II FINAL REPORT

VOLUME I

EXECUTIVE SUMMARY

6. 8 January 1981

(E82-10254) NASA/BLM APPLICATIONS PILOT TEST (APT), PHASE 2. VOLUME 1: EXECUTIVE SUMMARY Final Report (Electromagnetic Systems Labs.) 85 p HC A05/MF A01 CSCL 08B

N82-24532

Unclas

G3/43 00254

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5. NASA Contract
NAS9-15740

ESL INCORPORATED
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Sunnyvale, California

8 January 1981

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NASA/BLM APT FINAL REPORT
VOLUME I: EXECUTIVE SUMMARY

1.0 INTRODUCTION.

1.1 Organization of Final Report.

The final report for the Phase II activities on the NASA/BLM Applications Pilot Test (APT) is divided into three stand-alone documents. Volume I is the Executive Summary, and as such describes the Phase II project in general terms on objectives, procedures and results. Volume II, Technology Demonstration, describes the methodology and results of the vegetation mapping and inventory activities for the Arizona Test Site. Volume III, Technology Transfer, details the training courses presented to BLM personnel on the integration and use of remotely sensed data for mapping and inventory requirements as implemented during the Phase II project.

1.2 Background and Direction of APT.

The basis of the current APT program jointly being carried out by NASA and BLM was a remote sensing research project contracted by BLM to the University of California, Berkeley (Colwell 1975). That project, popularly referred to as the Susanville Program, took place in BLM's Susanville District in Northeastern California and Northwestern Nevada in the 1973-74 time period. Although the program was concerned with remote sensing in its most general terms, a number of specific applications of Landsat and aerial photography at various scales were investigated. An analysis of output products from that study concluded that certain information extracted from satellite data and supported with other stages

1.2 --Continued.

of data could be used to prepare unit resource analyses and thence for management framework and activity planning. Specifically, the Susanville Program developed vegetation cover maps and production estimates.

As a result of this experience personnel from BLM and NASA met in May 1975 to explore the basis for a joint remote sensing project. At BLM's suggestion, an inventory of wildland vegetation was selected since vegetation plays a role in all BLM resource activities (lands, wildlife, minerals, recreation, watershed, range, and forestry). By February 1976 a project had been prepared and in November 1976 a memorandum of understanding between BLM and NASA was signed. The NASA/BLM program was initiated as an Application System Verification and Transfer (ASVT) and was later changed to an Application Project Test (APT). The program undertaken was a phased three year project which encompassed three test sites: in Alaska, in Arizona, and in Idaho respectively. The program was designed to initially expose the user agency (BLM) to technological concepts and procedures in remote sensing and thereafter to have BLM assume an ever increasing responsibility for the conduct of the program. At its conclusion total responsibility for planning and implementation will reside with BLM. The first (Alaska) phase was carried out by NASA working through a contractor (ESL Incorporated) and was for the purpose of vegetation cover mapping in a test site representative of a northern spruce tundra biome. During this phase BLM assisted with the field work, with ~~the~~ digital processing and analysis and with monitoring the contract. The second (Arizona) phase of the APT program has included both vegetation cover mapping and range, woodland, and forest production estimation. The former task (cover mapping) is being carried out by BLM. The latter task, to which this report is primarily directed, is being

1.2 --Continued.

carried out by ESL Incorporated under contract with NASA. The Phase II site is located in extreme Northwestern Arizona and is typical of the southwest desert and upland communities. The third (Idaho) phase is to include both vegetation cover mapping and range forage production estimation, both tasks in this case being carried out by BLM. The Phase III site lies in Southwestern Idaho and is typical of a Great Basin sagebrush/ grassland community.

A joint planning session including NASA/JSC, BLM/DSC and Arizona Strip District, and ESL and their subcontractors was conducted on October 3-4, 1978 prior to beginning the contract effort for Phase II in Arizona. The purpose of the session was to finalize project philosophy, objectives and schedules and workshop (training) content, attendees, location and schedule. A similar session at the beginning of Phase I in Alaska was very helpful as a beginning point in that the participants were able to exchange views and have an overall view of the tasks to be accomplished.

ESL has prepared a flow chart with a schedule of tasks and tentative dates. Using this as a starting point, a final flow chart of events for the entire Phase II effort was developed. A copy is included as Appendix I. Although changes were required, the flow chart was an invaluable tool as a reference point for identifying the impact of changes on other events and schedules.

1.3 Overview of Phase II Project Objectives.

The primary objective in Phase II was the demonstration of the integration of remote sensing technology with existing techniques for producing a vegetation type map and vegetation productivity estimates. A parallel objective was the transfer of this technology to BLM personnel to promote the implementation and utilization of the procedures and techniques within

1.3 --Continued.

the BLM operations framework. The technology being demonstrated emphasized the integration of quantitatively-based remote sensing data while maintaining consideration of cost-efficiency in the implementation of the overall design. The technology transfer expanded on this emphasis with particular attention on further developing the understanding, on the part of BLM, of approaches to inventories that integrate multiple data sources given various resource information objectives. Specifically, any considerations based on the candidate approaches were focused on sampling strategies and analyses of the costs of data collection as specified by those strategies.

1.4 Overview of the Approach.

1.4.1 Technology Demonstration.

The technology demonstration aspect of Phase II combined data from Landsat, low-altitude color aerial photography and ground visits to produce the vegetation type map as well as the productivity estimates for range, woodland and forest resources. One Landsat scene covering the Arizona Test Site was selected for computer-aided processing to provide the basis of the type map and to control the productivity sampling efforts (Section 2.1). Photo-interpretation results from large scale (1:750 - 1:1200 scale) color aerial photography was used to describe the vegetation characteristics of the spectral classes derived from the Landsat processing (Section 2.2). Also, estimates of parameters related to productivity were made from the aerial photography to be combined in a double-sampling framework with ground measurements of productivity. Photo data and ground data were combined through specially designed formulae to produce the necessary productivity estimates and also the vegetation species composition descriptions for each spectral class (Section 2.3). Map-type outputs were created based on

1.4.1 --Continued.

the Landsat data and the related class descriptions and, for some maps, productivity information was also included (Section 2.4).

1.4.2 Technology Transfer.

The technology transfer portion of Phase II was divided into three parts consisting of a planning session, workshops (two) and project status reviews (four). The planning session was held at the outset of the project to familiarize project participants with the full scope of the work to be performed and to establish a milestone schedule (Section 3.1). The two workshops were held to provide "hands-on" instruction for project participants in specific Phase II technology areas and utilized actual project data (Section 3.2). The four project status reviews were held periodically through the life of the project to maintain continuity in reporting on interim results, to resolve any problems that occurred and to update the project schedule as necessary (Section 3.3).

2.0 TECHNOLOGY DEMONSTRATION.

2.1 Landsat Data Processing.

2.1.1 Objectives.

Given the technology objective of a vegetation type map and productivity estimates for range, woodland and forest resources, computer-aided digital classification of Landsat satellite data was selected as a major source of input data. Specifically, the classification results would provide the basis for the vegetation type map as well as the sampling frame for the productivity estimation tasks. The sample allocation, sample selections and

2.1.1 --Continued.

tabulations of estimate summarizations all would use the Landsat classification.

2.1.2 Procedures.

The Landsat data processing for this project was divided into six major categories:

1) Preprocessing
2) Training
3) Classification
4) Stratification
5) Class Description
6) Digital Terrain Data

Preprocessing. Landsat digital data requires a certain amount of manipulation before it can be used effectively and efficiently in a resource assessment/inventory project. To be used more effectively, the data is placed into the proper format, corrected for radiometric and geometric distortions, and related to a preselected ground coordinate system. To be used more efficiently, the project area is extracted from the appropriate Landsat scenes to eliminate unnecessary manipulation of data that is outside project boundaries.

Training. Unsupervised and supervised training procedures were utilized to generate the spectral statistics to be applied in the maximum likelihood classification algorithm used to classify the Landsat data. The unsupervised approach was used first to develop an initial set of training statistics. Preliminary classification based on those statistics performed on four subsections of the project area was evaluated for completeness. Based on that evaluation, specific training sites were selected and added to the original set of spectral statistics in

2.1.2 --Continued.

order to improve the results from the preliminary classification. The overall training procedures generated 83 spectral clusters (distinctly separable spectral responses identified in the Landsat data) to be used in classifying the Landsat data. It is important to note that at this point there was only a general vegetation type description associated with each cluster. The subsequent sampling/photo-interpretation procedures (Section 2.2) developed detailed quantitatively based vegetation descriptions.

Classification. The 83 spectral clusters were applied in a maximum likelihood classification algorithm to the raw Landsat data covering the project area. The output of this step was a computer classification with 83 spectral classes generally related to the vegetation of the area. These classes were evaluated by BLM-Arizona personnel for potential of any spectral class representing more than one vegetation type. After all such "confusions" were noted, it was determined that an environmental stratification could be used to eliminate them.

Stratification. Two types of stratification were applied to the Landsat data: administrative and environmental. The administrative stratification partitioned the project area into selected pastures and grazing allotments. This would be used to control the sampling and data summarization of the productivity estimation tasks. The environmental stratification divided the area into low desert, high desert, mountain, and forest types. This was used to assign new class identifiers to those spectral classes occurring in more than one environmental strata.

Class Description. In order to sample the classification most efficiently and to reduce the total number of samples required, it was necessary to progress from the general vegetation descriptions of the detailed spectral classes to preliminary

2.1.2 --Continued.

vegetation composition estimates for a set of summary classes. Based on the general vegetation type noted for each detailed spectral class, spectral similarities between classes and proximity of locations between classes within the environmental strata; the detailed spectral classes were grouped into a set of summary classes for subsequent sampling and estimation. These summary classes were then combined with existing photo interpretation data over the project area in a one-way analysis of variance to produce estimates of the average percent composition of each class in terms of trees, shrubs, grass, and non-vegetation. The summary class descriptions were major inputs in determining sample size, allocation and selection.

Digital Terrain Data. The final step in the Landsat processing phase was to input and register digital terrain data with the Landsat data for use in the vegetation mapping task. The detailed descriptions of spectral classes to be generated following the sampling of the above summary classes would be augmented by topographic information. Specifically, for each class the ranges of elevation, slope and aspect would be determined and then included with the species composition descriptions. This terrain information is reported so to further explain any spectral class differences due to topographic influences.

2.1.3 Landsat Processing Results.

The training steps produced 83 spectral clusters (training statistics) to be used in classifying the raw Landsat data. Elimination of "confusion" classes utilizing the environmental stratification resulted in expanding to 117 detailed classes from the original 83 classes. Class description steps grouped the 117 classes into 27 summary categories as shown in Table 2-1. The sections following describe the sampling,

Table 2-1. Results of Assignment of All Spectral Clusters to Summary Categories.

Summary Category	Strata	Description	Spectral Clusters
1	Low Desert	Creosote-Bursage (rocky soil)	1,2,7,10,11,87,88, 89,90,91,92,93,98, 100
2	Low Desert	Creosote-Bursage (sandy soil)	3,5,9,86,94,95,99
3	Low Desert	Creosote-Pure	4
4	Low Desert	Upland Desert Shrub - Creosote Dominant	6,12,13,14,96,97
5	Low Desert	Blackbrush	45
6	Low Desert	Mixed Desert Shrub - Creosote and Cactus	8,74
7	All	Riparian Woodland	25,26,27
8	High Desert	Shrub-Grass	28,34,38
9	High Desert	Grassland-Shrub	31,39
10	High Desert	Snakeweed-Grass	29,30,106,107,108
11	High Desert	Sage-Mix Shrub	32,44,102,103,105, 111
12	High Desert	Sage	35,49,51,54,55, 110,112
13	High Desert	Saltshrub	36,37,104,109
14	High Desert	Pinyon-Juniper-Sage	33,50
15	High Desert	Pinyon-Juniper-Shrub	53,56,57,58,59,61, 62,63,84,85
16	High Desert	Pinyon-Juniper	40,41,46,52
17	Mountain	Mountain Shrub	42
18	Mountain	Mixed Chaparral	60,113
19	Low Desert	Agriculture	15,16,17,18,19,20, 21,22,23,24,114
20	Mountain	Ponderosa Pine-Oak	66

Table 2-1. --Continued.

Summary Category	Strata	Description	Spectral Clusters
21	Mountain	Ponderosa Pine-Mix	65
22	Mountain	Ponderosa Pine	64
23	All	Shadow	47,83
24	All	Water	67,68,69,70,71,72, 73,82
25	All	Bare	76,77,78,79,80,81
26	Low Desert	Upland Desert Shrub-Blackbrush	43,48,75
27	High Desert	Sage-Grass	101,115,116,117

2.1.3 --Continued.

estimation and vegetation mapping phases and their utilization of the digitized administrative boundaries and digital terrain data.

2.2 Data Collection.

2.2.1 Overview of Sample Design.

The general sample design used in this project could be described as two-stage with double sampling. The first stage was a rectangular grid of primary sample units (PSUs) with dimensions of 2000 meters (east-west) by 450 meters (north-south). A set of those PSUs was selected for coverage with large scale (1:750 to 1:1200 nominal scale) aerial photography (LSP) from which to derive the PSU estimates. The second stage was a double sample of photo plots and ground plots from within designated PSUs. Rangeland, woodland and forest types were sampled independently of one another even though the PSUs for each were defined by a common grid. Other features of the design varied with the vegetation type being sampled as described in the following paragraphs.

2.2.1.1 Rangeland.

The quantities to be estimated were pounds per acre and kilograms per hectare of palatable forage for cattle within ten specified allotments. Figure 2-1 illustrates the locations of those allotments within the project area. The BLM-specified precision requirement for the estimates was as follows: the allowable sampling error for the overall forage estimates was ±20% at the 80% confidence level. The results were to be tabulated by vegetation strata (as defined by Landsat processing) and also by pasture and allotment. The primary results were to be total available palatable forage for cattle adjusted for utilization. The secondary results were to be current palatable forage

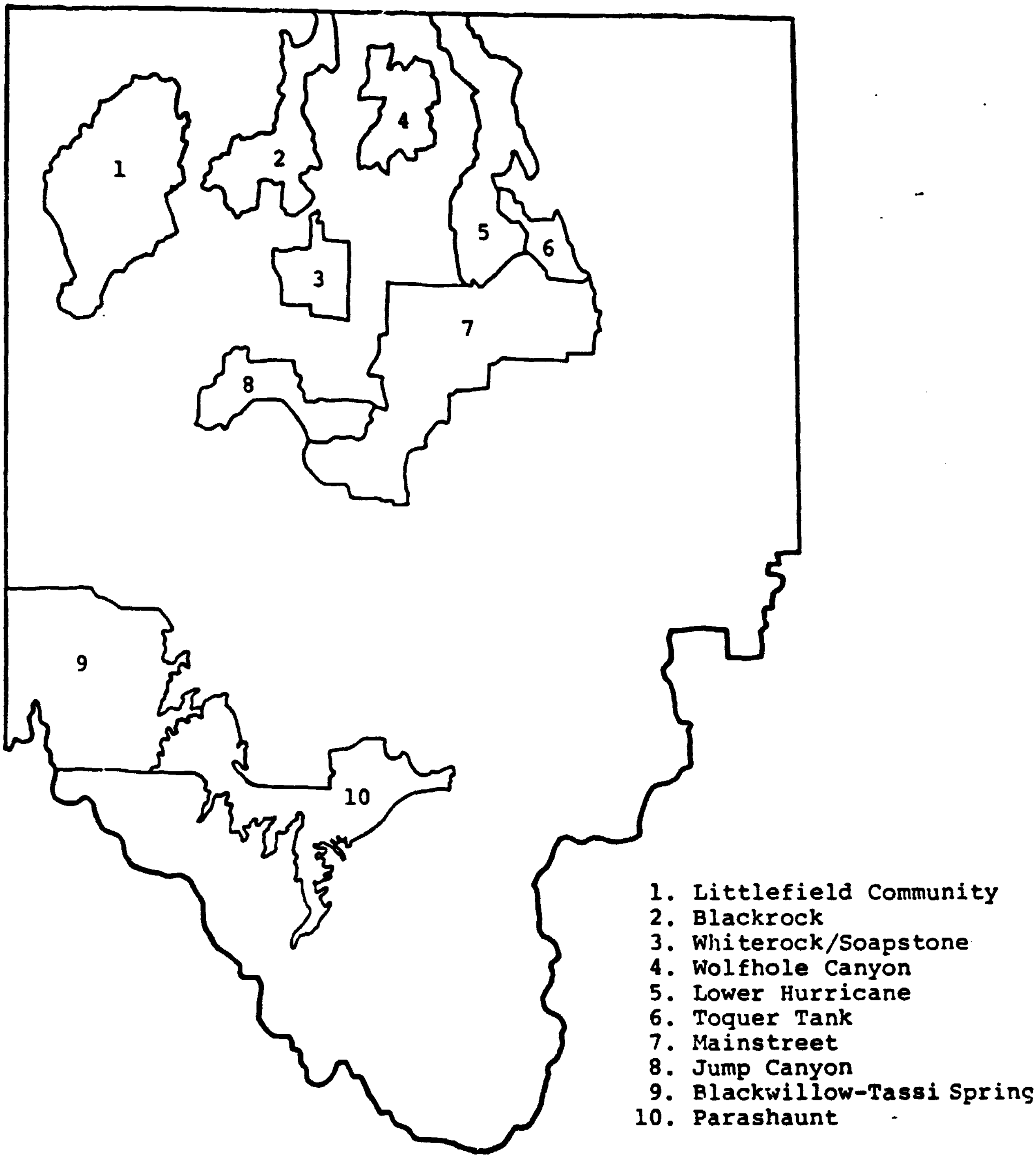


Figure 2-1. Range Allotment Boundaries.

2.2.1.1 --Continued.

whether available or not. The vegetation stratum estimates were to have 80% confidence intervals. For the total estimates across all strata, the precision requirement would be met if one-half the length of the 80% confidence interval was no more than 20% of the actual estimate.

To allocate and select samples, the sample design went through an optimization process. A Survey Planning Model (SPM) developed at the University of California by the Remote Sensing Research Program applied summary class description data (Section 2.1.3 Landsat Processing Results) to create a model representative of the magnitude, variability, and spatial distribution of forage from grasses, shrubs and forbs for 14 vegetation strata (1, 2, 3, 6, 8, 17/18, 9/12/27, 10/13, 11, 14, 15, 16, 21, 26 from Table 2-1). The SPM combined this data with cost information for collection and analysis of the photo and ground data as well as the 20%/80% precision requirement by means of a non-linear programming procedure to optimize the sampling method, number of samples and allocation to strata. The result was a stratified two-stage design with Landsat providing the stratification. The first stage was to select 108 primary sample units of size 450 meters by 2000 meters to be used as locations of the second stage sampling units. These PSUs were selected with equal probability from within the 14 vegetation strata. The second stage was in itself a double sample of aerial photo plots and ground plots. Each of the 108 PSUs was to be flown with large scale aerial photography such that each was composed of 15 photo plots at equal intervals. This resulted in a total of 1620 photo plots which were to then be photo interpreted for assignment into cover type strata (1447 feil within the strata of interest) and 135 sample plots were selected from the 14 vegetation strata of interest for ground measurement. Each ground plot was to be subsampled by five parallel transects of 40 subplots each for a total of 200 points per ground plot.

2.2.1.2 Woodland.

The quantities of interest were cubic foot volume per acre and cubic meter volume per hectare for pinyon pine and juniper. Size (diameter) and age were also of interest. The precision requirement was the same as for rangeland: estimates within ±20% at the 80% confidence level. The results were to be tabulated by allotment (see Figure 2-2) and 80% confidence intervals were to be supplied for each. For the total estimates across all three allotments, the precision requirement would be met if one-half the length of the 80% confidence interval was no more than 20% of the actual estimate.

A sample design optimization process was used similar to the rangeland case to specify sampling method, number of samples and allocation to strata. The SPM created a model representative of the magnitude, variability and spatial distribution of pinyon/juniper volume for the three woodland strata identified and described during the Landsat processing phase. Based on the volume model, the costs associated with data collection and the precision requirements, a two-stage design was again specified. The first stage was to select 45 primary sample units with probability of selection proportional to the acreage of pinyon/juniper within each PSU. In contrast, rangeland PSUs were selected with equal probability. The second stage was again a double sample of photo plots and ground plots. With 15 equally spaced photo plots per flight line and one flight line per PSU, a total of 675 photo plots were to be available from which to select ground plots. Each photo plot was assigned to a cover type strata and samples for ground measurement were selected with equal probabilities from those plots falling in the strata of interest:

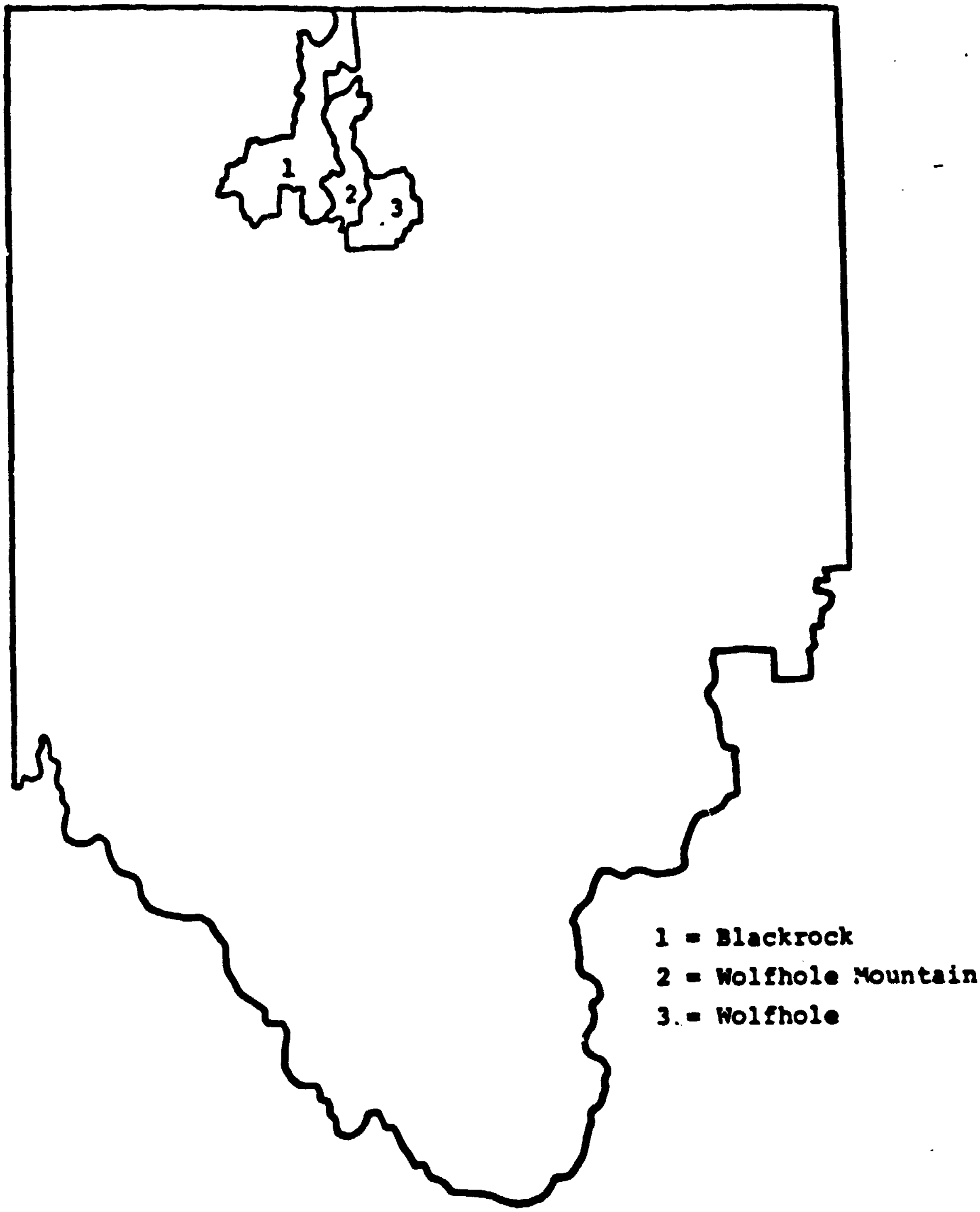


Figure 2-2. Woodland Allotment Boundaries.

2.2.1.2 --Continued.

Photo Stratum	No. of Photo Plots	No. of Ground Plots
Pinyon/Juniper/Sage	232	5
Pinyon/Juniper/Shrub	104	6
Pinyon/Juniper	155	5
Total	491*	16

*Reflects that the remaining 184 plots of the total 675 photo plots did not fall in the above strata.

There was also to be subsampling within the photo and ground plots using the line intersect method to select trees to be measured for volume estimation purposes. One of several templates (photo scale dependent) each with two parallel lines representing 75 feet each was to be overlayed on the photo plot. Any tree whose crown intersected a line would be photo interpreted for volume. For the 16 plots to be ground visited as well, the same photo interpreted trees were measured for volume on the ground.

2.2.1.3 Forest.

The quanitities of interest were ponderosa pine board foot volume per acre by stand (vegetation strata) for each area illustrated in Figure 2-3. The precision requirement, as in the previous cases, was ±20% at the 80% confidence level. The requirement would be met if for the combined areas one-half the length of the 80% confidence interval was no more than 20% of the actual estimate.

The sampling method, number of samples and their allocation were derived by the sample optimization process described for the woodland case above but used summary data for three ponderosa pine strata. The result was a stratified two-stage design where the first stage was to select 47 PSUs with equal probability from within the three strata. (In contrast, the woodland PSUs were selected with probability proportional to area.)

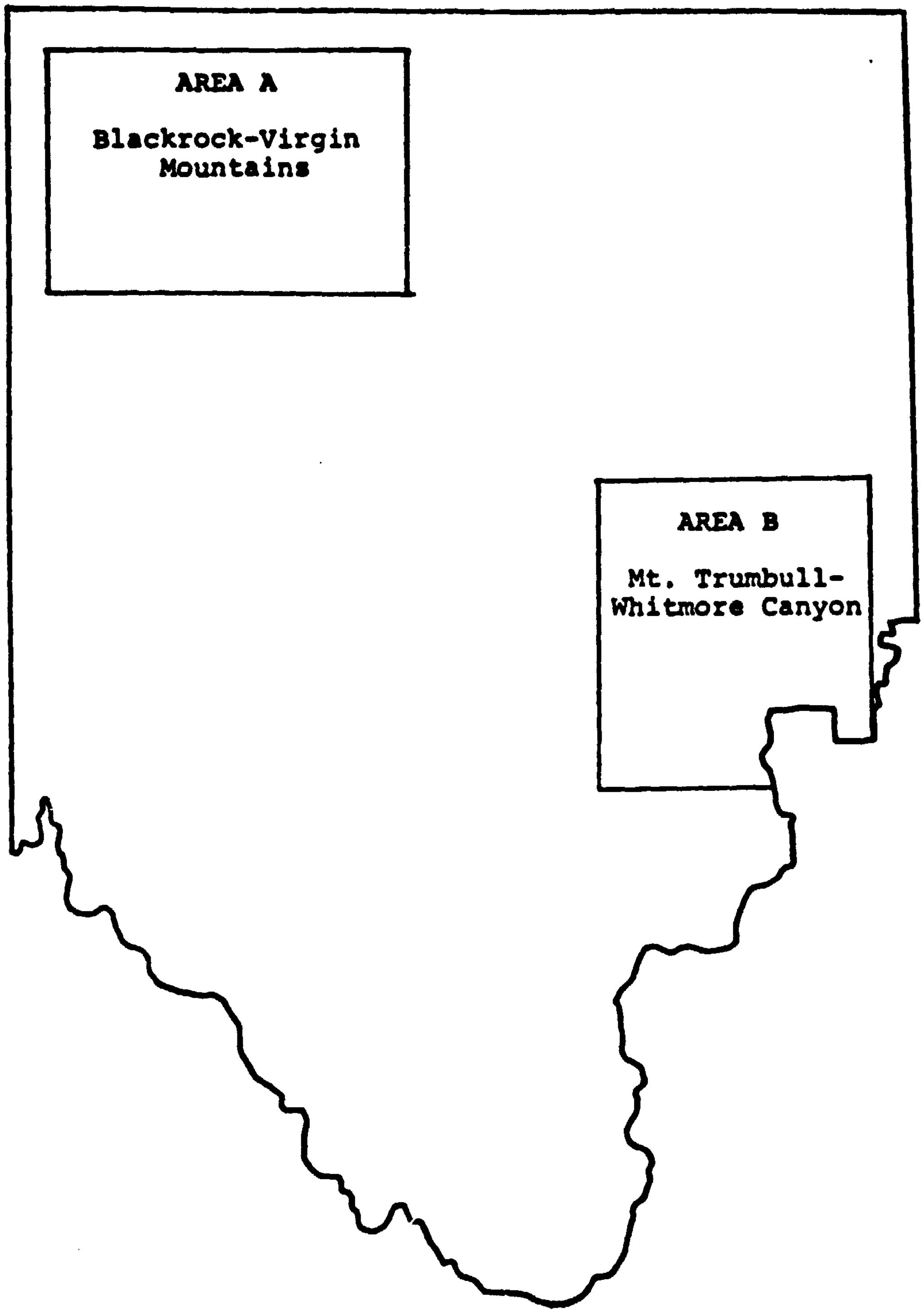


Figure 2-3. Map Depicting Forest Areas A and B Within the Arizona Test Site.

2.2.1.3 --Continued.

The second stage was a double sample of aerial photo plots and ground plots. Each PSU was covered with 15 photo plots at equal intervals for a total of 690 photo plots (one PSU photo set was unusable resulting in 15 less plots than anticipated). The photo plots were interpreted to be assigned to cover type strata and samples were selected from the ponderosa pine strata for ground measurements:

Stratum	# of PSUs Selected	# of PSUs Available	# of Photo Plots within strata	# of Ground Plots to Visit
Ponderosa Pine/ Oak	4	4	56	4
Ponderosa Pine/ Mixed Shrub	26	25	62	15
Ponderosa Pine	17	17	47	10
Total	47	46	165*	29

*Reflects that 525 of the 690 photo plots were not assigned to ponderosa pine strata.

There was subsampling within the photo and ground plots using the line intersect method as described for the woodland case in Section 2.2.1.2 above.

2.2.2 Summary of Allocation and Selection of Samples.

Results of the procedures described in the sample design overview above are summarized in the following table:

Vegetation	# of Strata of Interest	# of PSUs to Select*	# of Photo Plots Assigned to Strata of Interest	# of Ground Plots Selected
Rangeland	14	108	1447	136
Woodland	3	45	491	16
Forest	3	46	165	29
Total	20	199	2103	181

*Assumes loss of one PSU in forest type.

2.2.2 --Continued.

The number of photo plots above reflects that out of 2985 possible plots, only 2103 were assigned to strata to be sampled for productivity. All photo plots were interpreted for vegetation composition in producing the vegetation map of the area. Of the 181 ground plots selected, two forest plots did not contain any trees and therefore were not visited on the ground; and one range plot was on such steep ground that measurement was impossible. As a result, 178 ground plots were actually visited and the three missing plots were not replaced as this could have introduced unwanted bias into the productivity estimates.

2.2.3 Photointerpretation on the Large-Scale Aerial Photography.

As described above, each photo plot from the PSUs was initially interpreted to assign it to a cover type strata as part of the procedures to select second stage samples. There were, however, two more phases of photo interpretation: vegetation composition and productivity estimation. Each photo plot was first interepreted, independently of cover type assignment, for percent species composition and then used to describe the Landsat spectral classes. Finally, photo plots within the forest and woodland vegetation types were interpreted for tree volume estimates then used to estimate volumes for the Landsat summary classes (cover-type strata). These procedures are described in more detail below.

2.2.3.1 Vegetation Composition.

The large scale aerial photography (LSP) consisted of 35mm format color slides flown to achieve nominal scales ranging from 1:750 to 1:1200 (actual scales ranged from 1:500 to 1:3000 due to rugged terrain in some areas). An LSP photo plot was a stereo pair with the stereo overlap defined as the area of interest. There were 15 equally spaced plots along the center of

2.2.3.1 Continued.

the long dimension of each PSU (2000 meters by 450 meters) resulting in plot centers approximately 125 meters apart and each plot representing 60 feet to 100 feet square on the ground, depending on photo scale.

To combine the photo plot interpretation with the Landsat spectral classes, the location of each plot was identified on USGS quads and then digitized and transformed to the same ground coordinate system to which the Landsat data had been registered. This allowed matching of the Landsat classes to the interpreted data on a point-by-point basis.

Within the stereo overlap of each photo plot the following vegetation composition information was interpreted and recorded: identification of major plant species occurring on the plot, percent ground cover for each species, and also height class and foliar density by species. The interpretation was performed by one person to eliminate multiple biases that would occur by using more than one interpreter. Thus, any bias in the interpretations of the plot characteristics was constant.

2.2.3.2 Woodland and Forest Volume.

In addition to vegetation composition, trees were selected via the line intersect method to interpret for volume estimation on all plots from PSUs covering the forest and woodland vegetation types (676 photo plots out of the total 2985). One of several templates (depending on the plot photo scale) was overlayed in a predetermined manner (to ensure randomness) on to the stereo overlap portion of each photo plot. Each template had two parallel lines with each line representing 75 feet on the ground at the photo scale for which the template was prepared (a total of nine templates were prepared representing photo scales

2.2.3.2 --Continued.

from 1:500 to 1:3000 to accommodate the range of actual photo scales noted in the LSP). For a given plot, any tree whose crown touched one of the lines, information was determined and recorded as to its species (pinyon pine, juniper or ponderosa pine were the only species of interest), crown diameter (measured) and height (estimated to the nearest five feet).

2.2.4 Ground Data Collection.

The data collection procedures for the ground plots were designed to be as close to BLM procedures as the multistage design would allow. The procedures used on the range plots were modified from the Soil Vegetation Inventory Method (SVIM) while the forest and woodland procedures were based on the BLM Extensive Forest Inventory Field Handbook.

2.2.4.1 Range Plots.

Plot location was defined as the center point of the stereo overlap of a selected LSP plot. After locating it on the ground, this point was used as the center of a 200 point rectangular grid as formed by 5 lines with 40 points per line spaced evenly over a 42 foot by 48.75 foot area. These 200 points were used in determining species composition of the plot. A systematic set from the 200 points of 20 subplots (.1 square meter) were used to take SVIM shrub characterization and ocular weight estimates, recorded on modified SVIM field data forms. A subset of the ocular weight estimate plots were clipped, air-dried and weighed to use for adjusting the ocular estimates. This was done for each field crew member so as to have individually developed adjustments for a given plot based on who made the original ocular estimates.

2.2.4.2 Woodland and Forest Plots.

As described previously, plot location was determined by the parallel transects in the stereo overlap of each selected LSP plot. These transects were annotated on the LSP photos to be used in the field with the individual trees to be measured, marked and numbered to ensure correspondence with the photo interpretation data. For each tree, the following information was recorded: diameter (ground and stump height for woodland and breast height for forest), height, crown diameter, number of stems per tree (woodland) and age (on a subset of trees). Measurement of the distance between two photo-identified ground-located points was also recorded for use later in determining actual photo scale.

2.3 Productivity Estimation and Map Verification.

The following sections describe the steps and procedures used to combine the ground measurements, photo estimates and Landsat classification to produce the outputs specified by the project objectives.

2.3.1 Vegetation Type Mapping.

Before combining the Landsat classification results with the photo interpretation data (species composition), the 2985 photo plots were separated into two groups. The first group was composed of 2399 plots which were used to generate the vegetation descriptions of the Landsat classes. The remaining 586 photo plots, the second group, were used to verify those descriptions. This partitioning of photo plots was done in such a manner as to ensure that an adequate number of photo plots would be available to both describe and then verify the maximum number of Landsat spectral classes.

2.3.1 --Continued.

The photo data from each plot from the first group was then matched with the Landsat classification on a point-by-point class-by-class basis using analysis of variance techniques. This produced the mean and standard deviation of percent cover by species for each Landsat class. The same procedures were followed with the verification set of plots. BLM-Arizona personnel, using the vegetation descriptions for the 117 Landsat classes and checking locations of the classes within the project area, assigned each class to a category within the Arizona vegetation framework. This resulted in 14 Level III vegetation framework categories which could be aggregated further into 10 Level II categories. Table 2-2 shows the results of the assignments. The digital terrain information, elevation, slope and aspect was combined with the framework categories resulting from above to augment the species composition descriptions of each. Appendix II contains the "menu" descriptions (vegetation and topography) of each of the 14 Level III categories. The verification data set was compared with the original description set and it was noted that no significant differences existed between them. The descriptions of the vegetation framework classes and their locations (based on the Landsat data) were therefore considered accurate representations of the ground conditions in the project area.

Area estimates by vegetation type with 80 percent confidence intervals at the pasture and allotment level were generated by relating the Landsat class counts to their descriptions from the photo data through linear regression. In the example in Table 2-3, the "adjusted estimate" represents the regression coefficients applied to the Landsat area summaries. The "80% confidence" column represents an interval which has approximately 80% probability of containing the actual value.

Table 2-2. Assignment of the 117 Computer Classes to the Vegetation Framework.

	Vegetation Framework Classification		Computer Classes
1)	1--	Agriculture	15-24, 114
2)	211	Ponderosa Pine Forest	64, 65
3)	311	Pinyon-Juniper Woodland	33, 35, 41-43, 46, 47, 52, 53, 55-59, 61-63, 66, 83-85
4)	322	Riparian Woodland	25, 26
5)	412	Upland Desert Shrub	1-10, 12-14, 74, 75, 81, 86, 87, 89-100
6)	421	Great Basin Sagebrush	11, 28-30, 32, 34, 38, 40, 44, 48-50, 54, 101-103, 105, 106, 108, 110, 112, 115-117
7)	423	Blackbrush	88
8)	424	Other Tall Shrub	111
9)	425	Half Shrub	45
10)	432	Oakbrush	60, 113
11)	433	Other Mountain Shrub	27, 31, 39, 51
12)	511	Perennial Grassland	36, 37, 77, 104, 107, 109
13)	6--	Barren Land	76, 78-80
14)	7--	Water	67-73, 82

Table 2-3. Example of Area Estimates in Hectares by Allotment and Pasture.

. Vegetation Type: Pinyon/Juniper Woodland

ALLOTMENT PASTURE	LANDSAT-ONLY ESTIMATE	ADJUSTED ESTIMATE	80% CONFIDENCE
LOWER HURRICANE	489	494	285,703
ST. GEORGE	192	194	112,276
COYOTE	109	110	63,156
NORTH GYP	75	76	44,108
WEANING	3	3	2,4
SOUTH GYP	23	23	13,33
GRAVEL	60	60	35,86
PETE	23	23	13,33
HOLDING PEN	0	0	0,0
PARKER	1	1	1,1
FORCE	5	5	3,6
SELLING	0	0	0,0
TOQUER TANK	44	44	26,63
1	5	5	3,7
2	39	40	23,56
MAINSTREET	6807	6875	3971,9779
CECIL	7	6	4,9
ROUND POND	1	1	0,1
SQUARE POND	8	8	5,11
ANTHONY'S HIGLEY	16	16	9,23
CALVING	12	12	7,17
TEMPLE TRAIL	27	27	16,39
SALARATUS	63	64	37,91
MUDHOLE	19	19	11,27
TWIN TANKS	367	371	214,527
WARDS	23	23	14,33
DUTCHMAN	693	699	404,995
COX-ATKIN	1511	1526	881,2171
ENGLESTEAD	1973	1992	1151,2834
LITTLE JOE	2036	2057	1188,2925
BISHOP & BURR	53	53	31,76

2.3.2 Rangeland Productivity Estimation.

The data reduction process started with the air-dry weights of the species clipped on the various subplots of each range ground plot (see Section 2.2.4.1) and related these to the corresponding ocular estimates through linear regression ($R^2 = 77\%$). The resulting regression coefficients were then used to adjust the remaining ocular subplot weight estimates to produce current forage weight estimates, "available" or not, the secondary estimates. At this point, the availability and utilization factors were applied to produce the primary estimates: forage weights "available" whether "utilized" or not. Both types of estimates were carried through the remainder of the estimation process; however, at this stage all estimates for unpalatable species (for cattle) were deleted from the process. The adjusted estimates were averaged by species, weighted (statistically speaking) by the frequency of species occurrence in all subplots, and then summed to obtain forage weight estimates across all palatable species for each of the 135 ground plots.

As described previously (Section 2.2.1.1), the LSP was used as a stratification tool in selecting the plots to be visited on the ground. Attempts were made to correlate the ground-based estimates of forage weight with photo-interpreted values such as crown cover, the cover/density product, and the cover/density/height product, but the relationships were not strong enough to be useful. Consequently, for the range case, the LSP was used only for stratification and not estimation.

The ground-based weight estimates were related to their corresponding Landsat summary classes to produce weight estimates per unit area by class, including the associated 80% confidence interval for each. Forage weight estimates for the specified allotments were developed by ratio estimation. (See Appendix III for summary of estimates.)

2.3.3 Woodland Volume Estimation.

The ground-based measurements of diameter at stump height, total tree height and average crown diameter for trees selected using the line intersect method were converted to cubic foot volumes through BLM pinyon-juniper volume tables. The ground volumes were then related to the Photo values through multiple regression ($R^2 = 37\%$ for pinyon; 34% for juniper) to yield a tree volume prediction equation which could be used for all the photo-interpreted trees. These predictions were then expanded through an estimation procedure that used the tree crown diameters (which were proportional to the probability of selection for a tree) and the transect lengths to develop volume per acre estimates for each photo plot. These were then averaged by PSU and combined with PSU sampling weights to obtain the final cubic foot volume estimates (also converted to metric measure: cubic meters per hectare) for the three allotments of interest. Average diameter and age estimates were obtained from ground measurements alone. Estimates of precision were also produced using methods fitting the sample design and parameter estimation process. (See Appendix IV for summary of estimates.)

2.3.4 Forest Volume Estimation.

The ground-based measurements of diameter breast height and total tree height for trees selected by the line intersect method were measured and used to compute board foot volume using equations generated by the U.S. Forest Service (BLM-Arizona personnel designated these equations as acceptable ones to use for the area). These ground determined volumes were then regressed against the photo-interpreted values (height and crown diameter) for the same trees ($R^2 = 78\%$ for ponderosa pine) to yield a tree volume prediction equation which could be used for all the photo-interpreted trees. Both the photo and ground tree volume estimates were expanded to board foot per acre estimates for the entire plot by use of the crown diameters (which were proportional

2.3.4 --Continued.

to the probability of selection for a tree) and transect lengths. The matched photo and ground plot estimates were then related through regression for the Landsat strata sampled ($R^2 = 44\%$ for ponderosa pine/oak and ponderosa pine/mixed shrub; $R^2 = 76\%$ for ponderosa pine pure). A statified regression estimator was then used to obtain the final estimates by Landsat strata, and the associated precision estimates were also produced. (See Appendix V for summary of estimates.)

2.4 Costs Analysis.

The costs associated with this project were separated into recurring and non-recurring components. Only recurring costs were considered in this analysis. In other words, "false" starts, development of procedures, and non-special management costs were omitted to the extent possible. The objective of this analysis was to associate a cost per acre with both the vegetation mapping and the productivity estimation elements of this project. Table 2-4 summarizes this analysis and shows that at the average price per ESL manhour over the life of the project, the mapping effort for the 2.2 million acre site cost 3¢ per acre. The productivity estimation, performed on 550,000 acres, cost 16.3¢ per acre given the mapping had been performed. These figures were based on the costs associated with achieving the objectives and accuracies of this project. If similar projects were undertaken but with higher accuracy and precision specifications, it should be anticipated that the costs per acre could be greater.

2.5 Landsat Digital Products.

The Landsat digital hardcopy output products consisted of 4 application maps and 2 sets of color-coded classification images. The application maps were generated from the digital classification quantitative inventory and ancillary data in the

Table 2-4. Phase II Cost Summary.

Project Element	Total ESL Man-Hours	=	Mapping Component	+	Estimation Component	Additional Costs
Landsat Processing	570		450		120	
Multistage Sampling	270		120		150	4800[1]
Data Collection						
Photo Acquisition	50		50		-	11,300[2]
Photo Interpretation	700		500		200	
Ground Data Collection	100		-		100	31,970[3]
Productivity Estimation	1250		240		1010	700[1]
Output Products[4]						
Map Output	180		180		-	
Tabular Summaries	120		40		80	
Totals	3240		1580		1660	$48,770

Vegetation mapping cost = [(1580 hrs x $3.17/hr.) + 11,700]
÷ 2.2 million acres = 3¢/acre

Productivity estimation = (Given the mapping is completed and available)
= [(1660 hrs x $31.70/hr) + 37,470]
÷ 550,000 acres = 16.3¢/acre

1. RSRP, U.C. Berkeley, in survey planning model runs and estimation work.
2. Acquisition of 3000 large scale aerial photography plots.
3. Collection of ground data on 179 ground plots.
4. Does not include generation of final report.

2.5 --Continued.

form of digital terrain data and administrative data. The map products were:

a. Rangeland Suitability, defined as:

(1) current production of useable forage above 20 lbs. per acre,

(2) located within a four mile radius of water,

(3) slope less than 51 percent.

b. Potential Rangeland Suitability, defined as:

(1) current production of useable forage above 20 lbs. per acre,

(2) service area of water is greater than four mile radius,

(3) slope less than 51 percent.

c. Sagebrush Treatment Area, defined as:

(1) Great Basin sagebrush vegetation community,

(2) slope less than 15 percent.

d. Fire Flash Fuel Areas, defined as:

(1) annual grass and forbs cover 30 percent or greater of ground,

(2) aspect southwest - south - southeast.

These products were presented with a mapping minimum of 10 acreas (4 hectares) at a scale of 1:126,720 as a halftone grey-coded map on stable base transparency material. Maps 1 and 2 were limited to the 10 allotments sampled for range productivity. Maps 3 and 4 represent data over the full project area.

2.5 --Continued.

The 5th map output products were for the forest administrative area A and consisted of 8x10 inch Polaroid hardcopies of the color-coded computer class groupings. These products were presented at 10 acre (4 hectare) minimum mapping units for the Level II framework and for the Level III framework groupings developed by the BLM-Arizona personnel. An IDIMS computer compatible tape (CCT) was generated with this data for the full project area as well.

3.0 TECHNOLOGY TRANSFER ACTIVITIES.

3.1 Planning Session - October 3-4, 1978.

The objective of this session was to familiarize all project participants with the expected flow of tasks over the life of the Phase II efforts. The project flow chart in Appendix I was presented at this time. Also, the two training courses were discussed and finalized as to scope, content and dates. A preliminary set of milestone dates were established to be used in monitoring progress on the numerous aspects of the Phase II effort.

3.2 Seminars/"Hands-On" Training.

There were two training courses given to BLM-Arizona personnel during Phase II: Multistage Sampling-Field Workshop and the Data Analysis Workshop.

3.2.1 Multistage Sampling-Field Workshop, May 21-25, 1979.

This week long workshop/seminar covered the sample allocation, data collection and data analysis procedures used on the project. The objectives of the session was:

3.2.1 --Continued.

a. The development of a thorough, practical understanding of sample allocation procedures used on the project and the justification for the procedures.

b. To introduce and develop, from a practical standpoint, the statistical procedures and estimators being used on the project.

c. To further develop understanding of the optimization procedures being used with an emphasis on the factors that must be considered when designing an inventory and mapping project.

d. To further the understanding of the data sources being used on the project, including (1) the information extraction procedures, (2) relative level of accuracy and precision of each data source, (3) relative cost of acquisition and data extraction for each source, and (4) the risk associated with the use of data from each source.

e. To prepare the attendees for the data analysis workshop to be held at ESL in Fall 1979.

Participants in the course stated afterwards that the objectives were, in general, satisfied. The most frequent comment, however, was that of having a much greater appreciation for the complexity of resource inventory programs such as Phase II.

3.2.2 Data Analysis Workshop, November 13-16, 1979.

The objective of this course was to familiarize program participants with the procedures and techniques to be followed in reducing the data collected during Phase II to produce the

3.2.2 --Continued.

vegetation map and the productivity estimates. The course included presentations on analysis of variance, contingency analysis, regression analysis and ratio estimation procedures, all using actual data from Phase II. The most significant result of the course was the grouping of the 117 Landsat spectral classes into 14 Arizona vegetation framework Level III categories performed by the attending BLM-Arizona personnel.

3.3 Project Status Reviews.

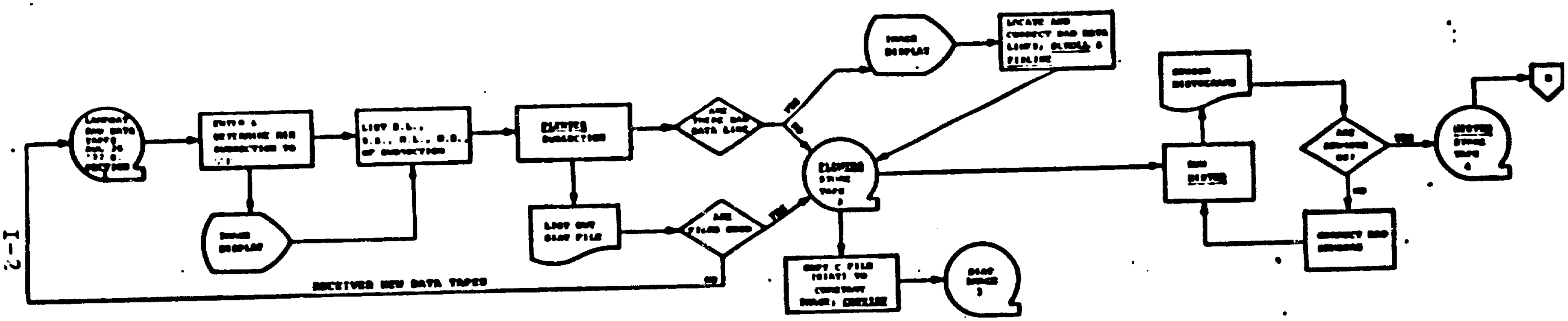
The objectives of these periodic reviews were to present progress to date on the Phase II effort and identify and resolve any problems noted or anticipated. The four in-progress reviews were held in January, June, September, and November, 1979. These reviews were considered extremely valuable in maintaining involvement in the project by all BLM, NASA and contractor participants. Coupled with the training course, the reviews provided an excellent means of exchanging information on the project: its objectives, the procedures, the problems encountered and their solutions and the results.

A final project review was held on 29-30 May 1980 to present the accomplishments and results of Phase II to a larger audience than that addressed at the status reviews. In the words of the NASA Project Manager for this APT, "Overall, I considered the Phase II Final Review as a successful culmination of a very rewarding and productive project. The success can be directly attributed to the cooperation and determination of the people involved from both BLM and the contractor."

APPENDIX I

PROJECT FLOW DIAGRAM

The following flow diagram illustrates the order of the detailed tasks and their interrelationshipa with other tasks that were necessary to completely define the approach to the Phase II technology demonstration.



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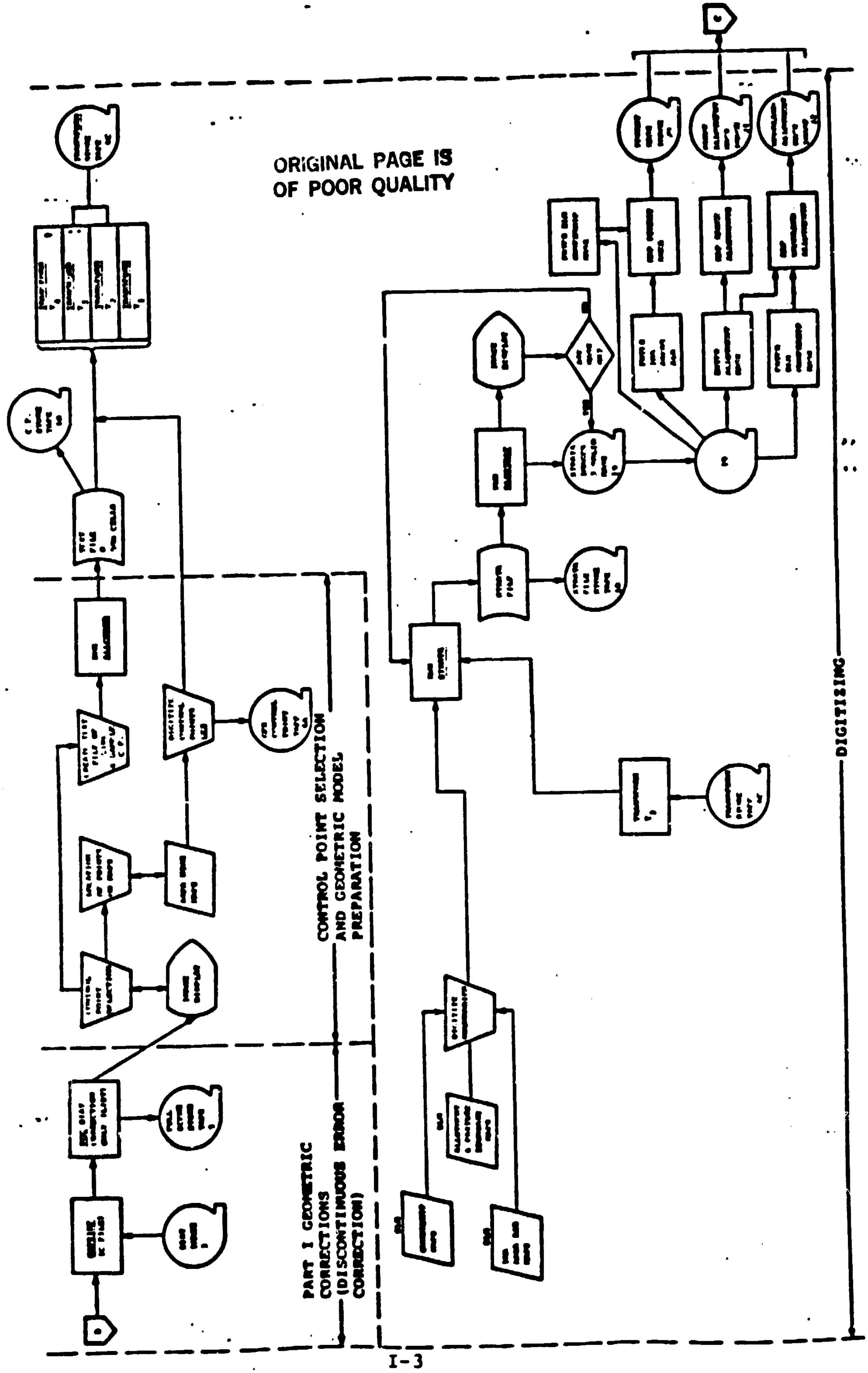
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CORRECTIONS
(DISCONTINUOUS ERROR
CORRECTION)
CONTROL POINT SELECTION
AND GEOMETRIC MODEL
PREPARATION
DIGITISING

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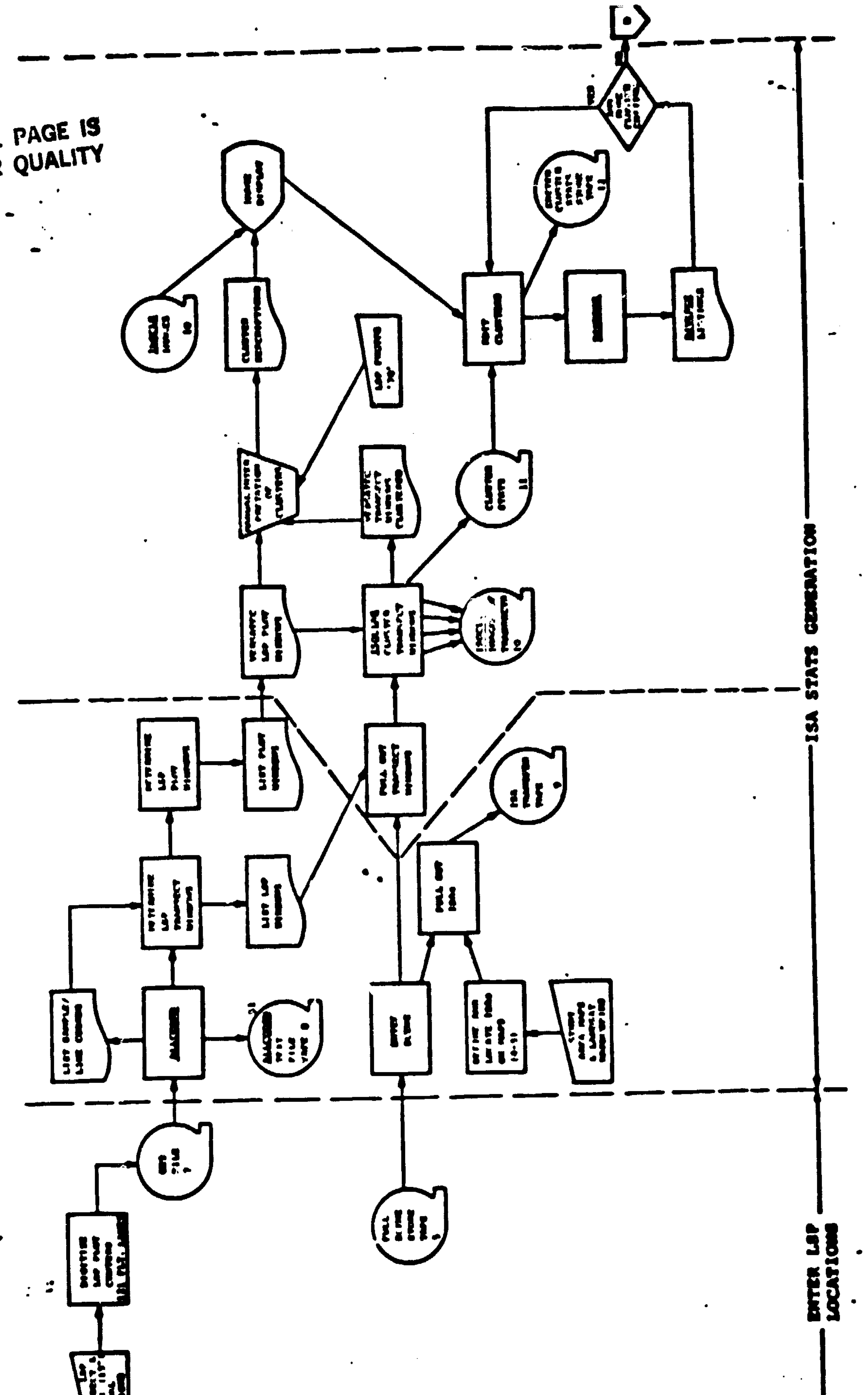

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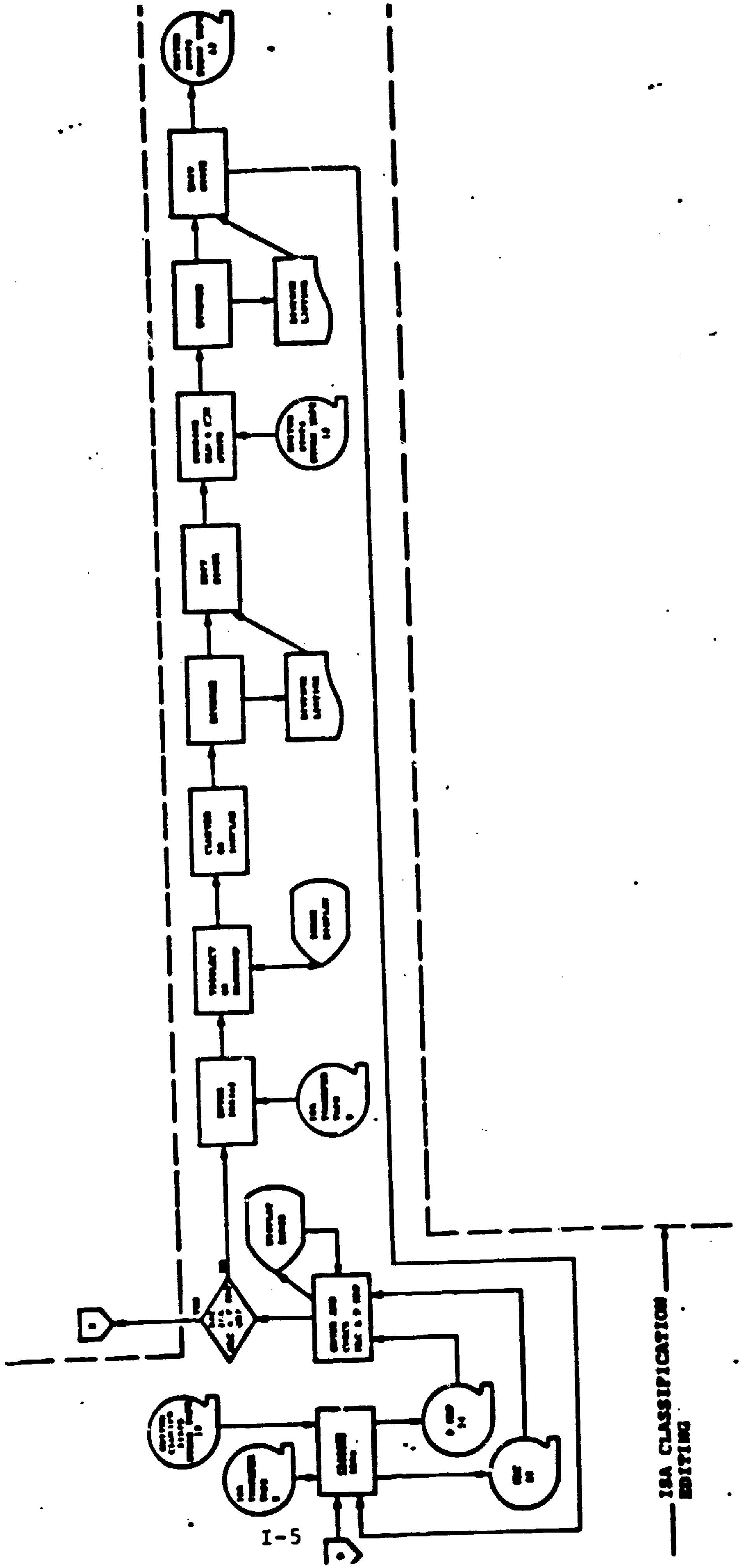

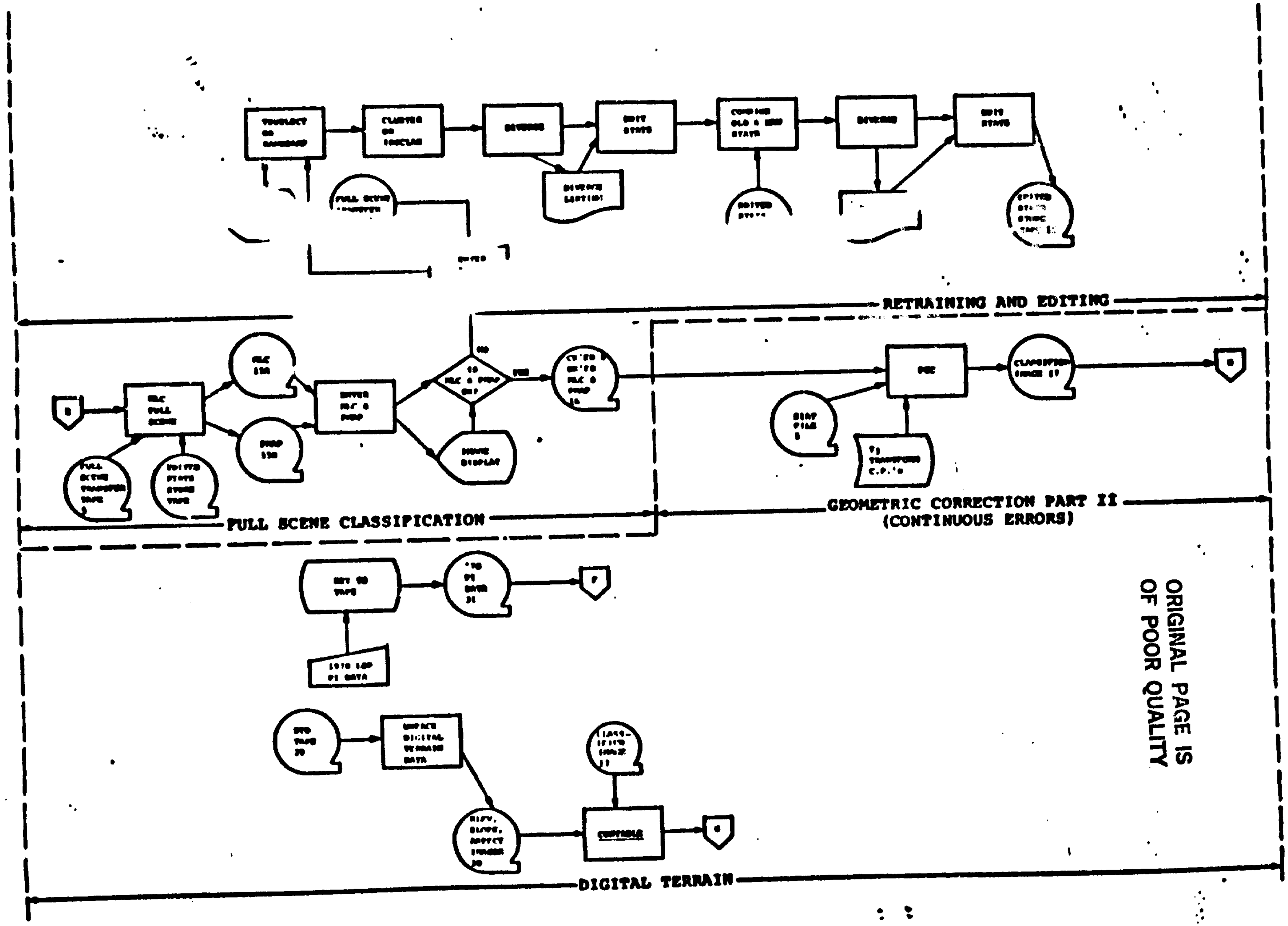
RETRAINING AND EDITING
FULL SCENE CLASSIFICATION
GEOMETRIC CORRECTION PART II
(CONTINUOUS ERRORS)
DIGITAL TERRAIN

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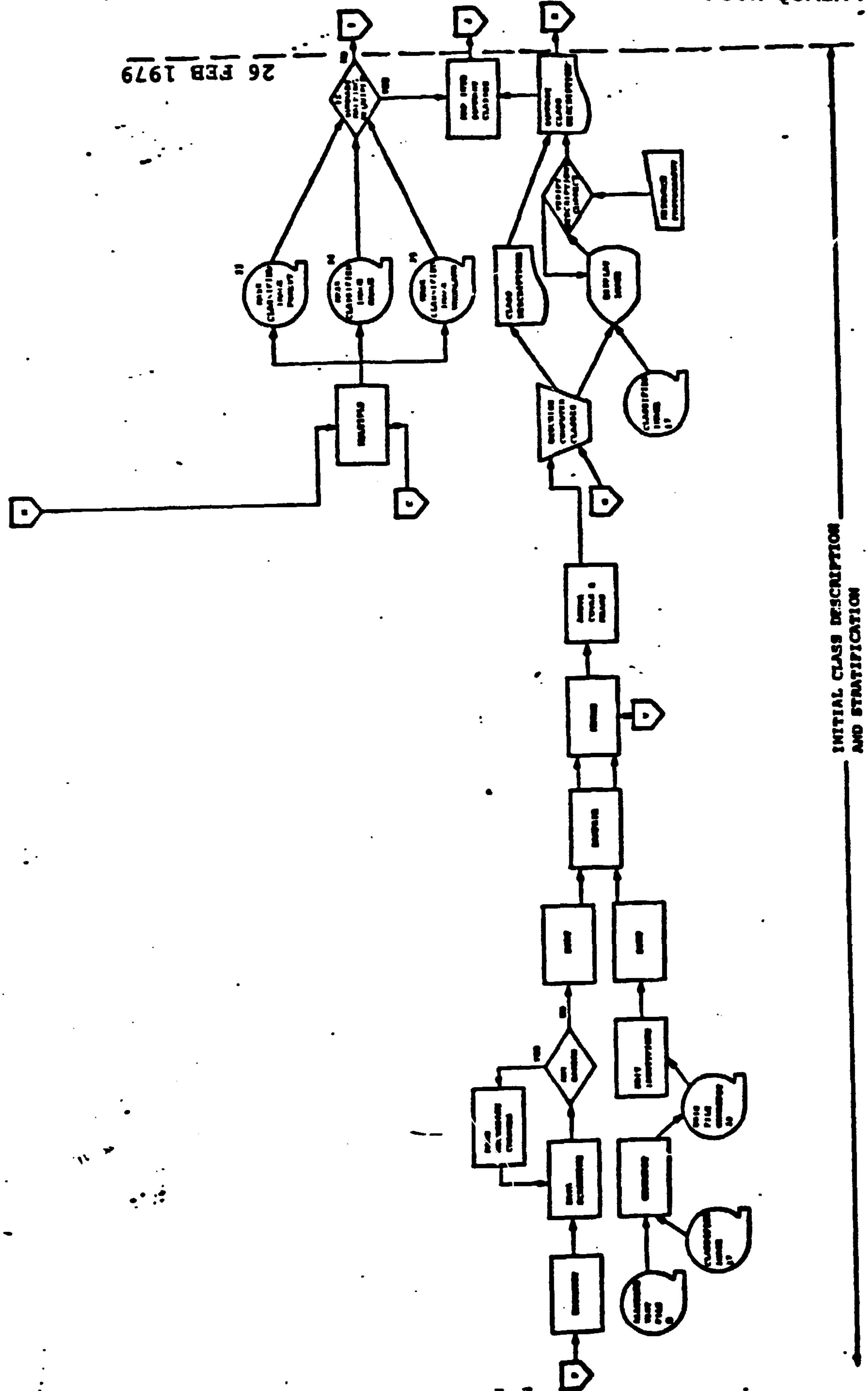
26 FEB 1979



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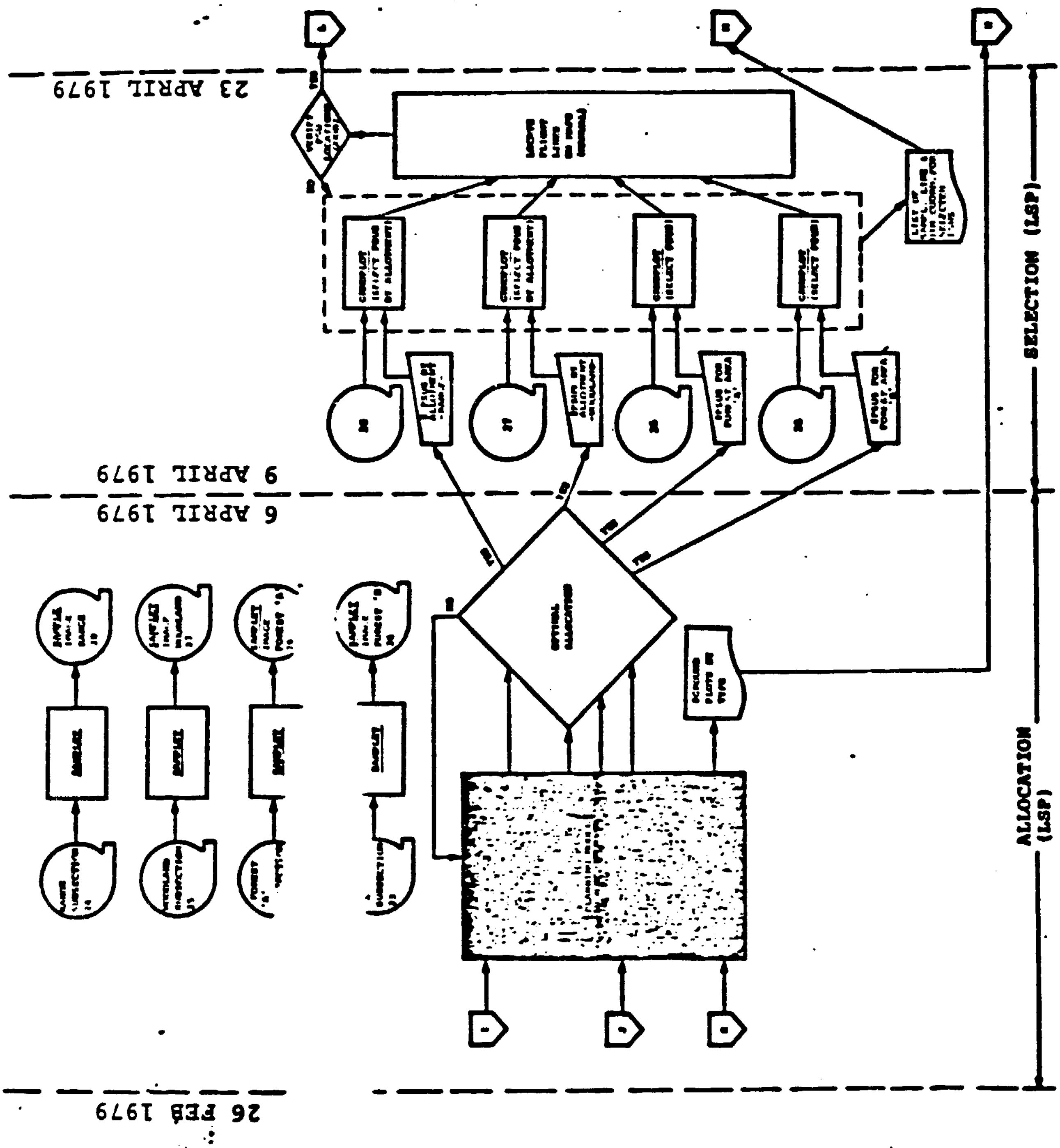
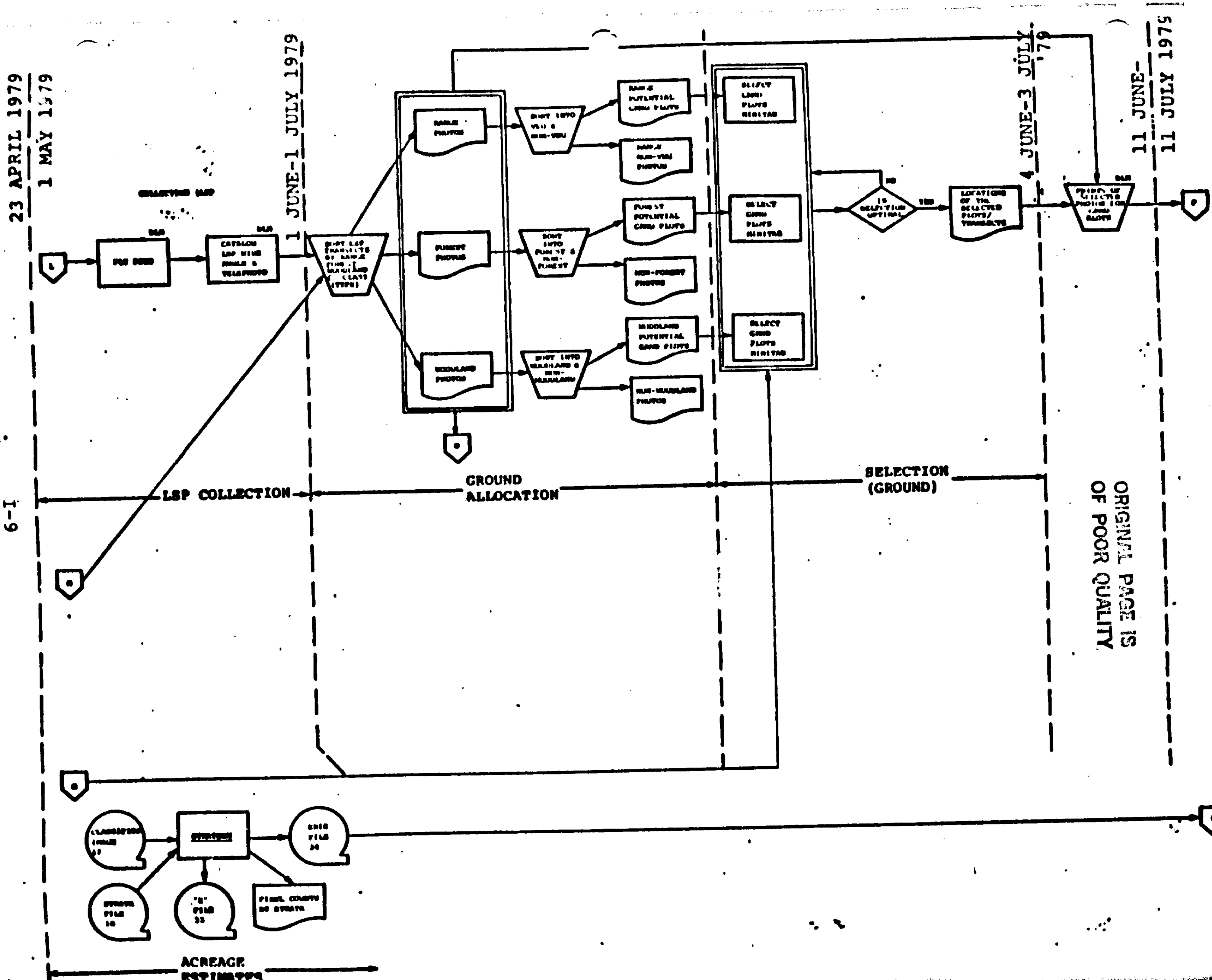
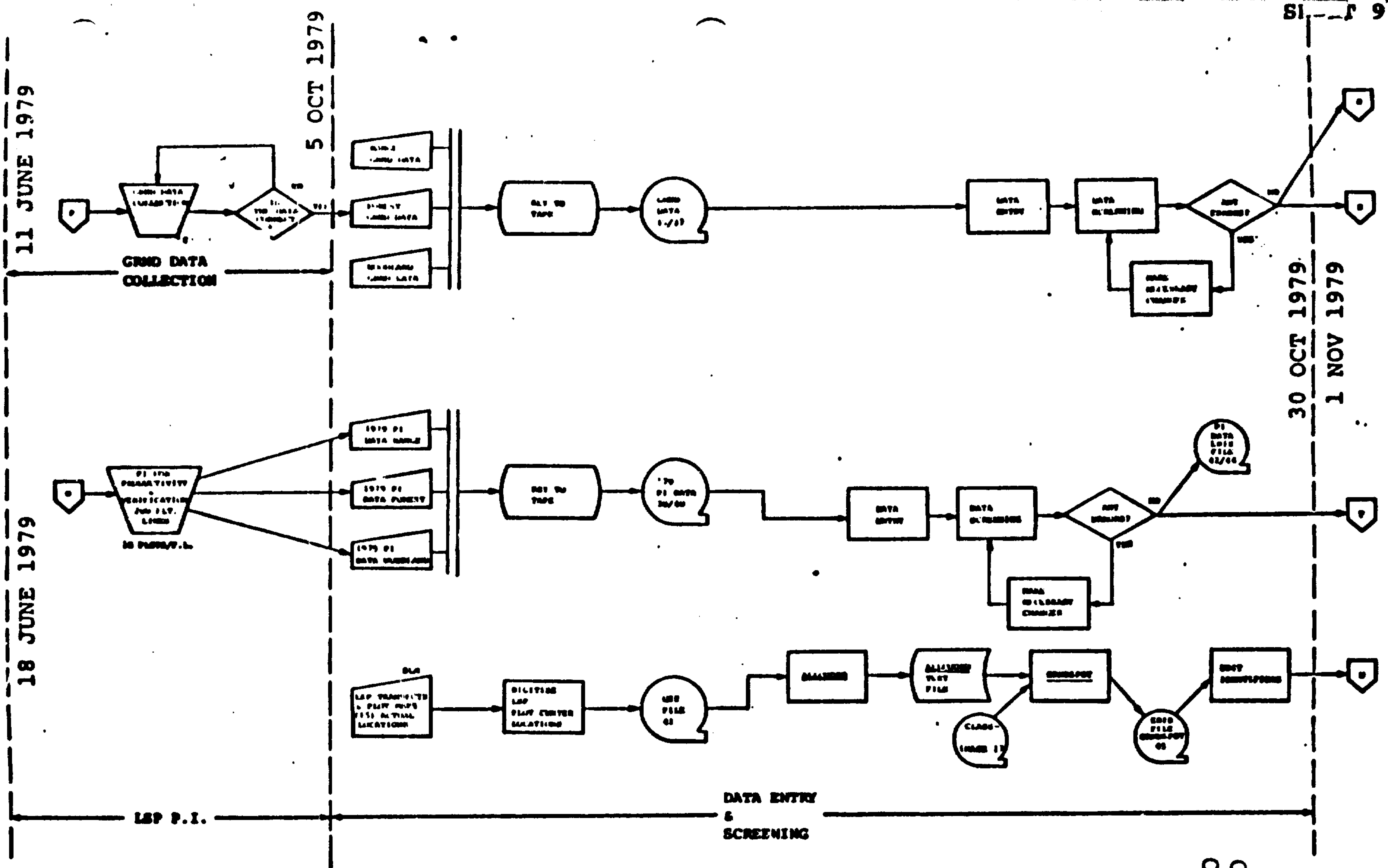



23 APRIL 1979
1 MAY 1979
1 JUNE-1 JULY 1979
4 JUNE-3 JULY '79
11 JUNE-
11 JULY 1975
LSP COLLECTION
GROUND ALLOCATION
SELECTION (GROUND)
ACREAGE
NON-FOREST PHOTOS
NON-WOODLAND PHOTOS
IS SELECTION OPTIMAL
YES
NO
LOCATIONS OF THE SELECTED PLOTS/TRANSECTS



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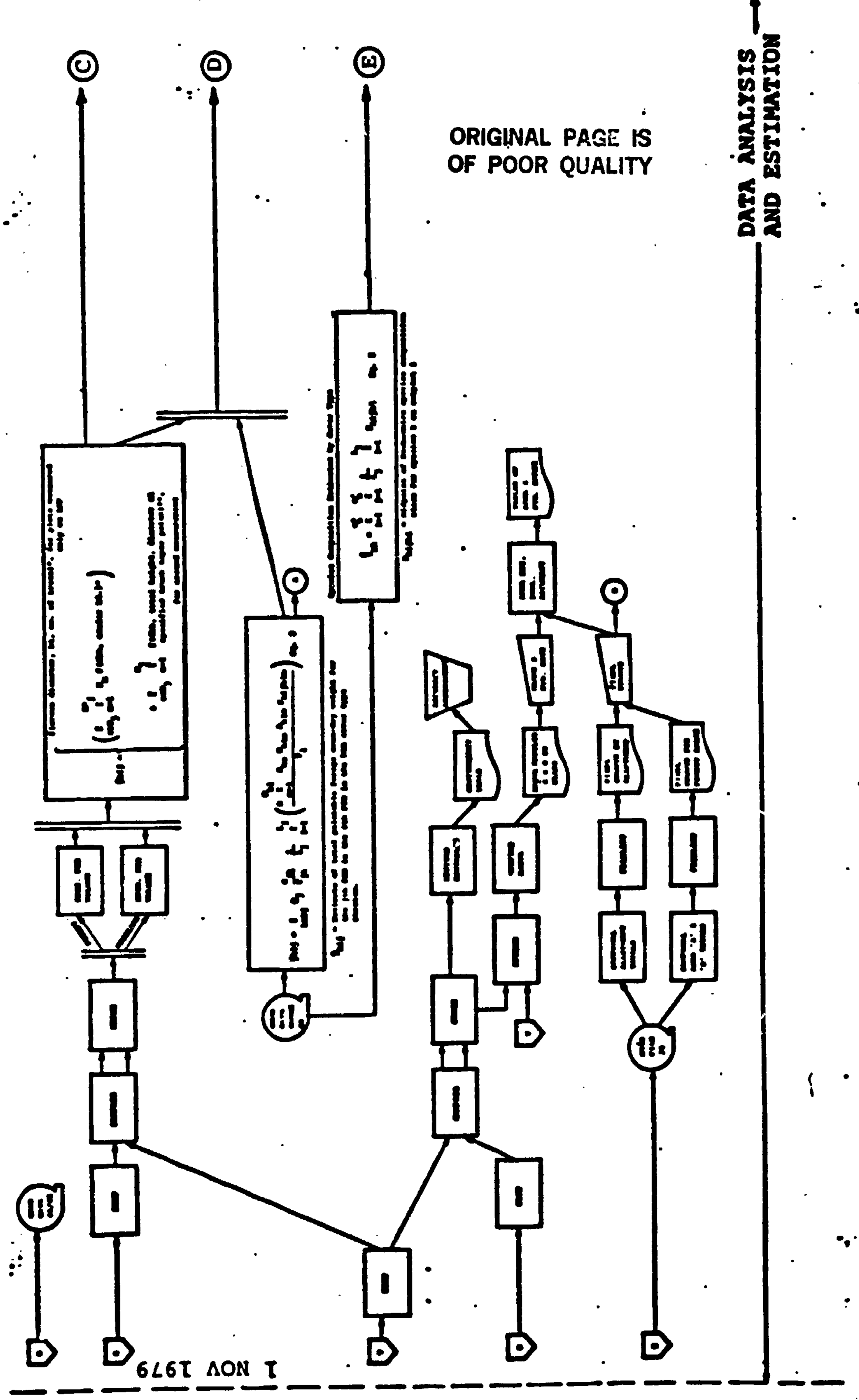
C
D
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DATA ANALYSIS
AND ESTIMATION
1 NOV 1979

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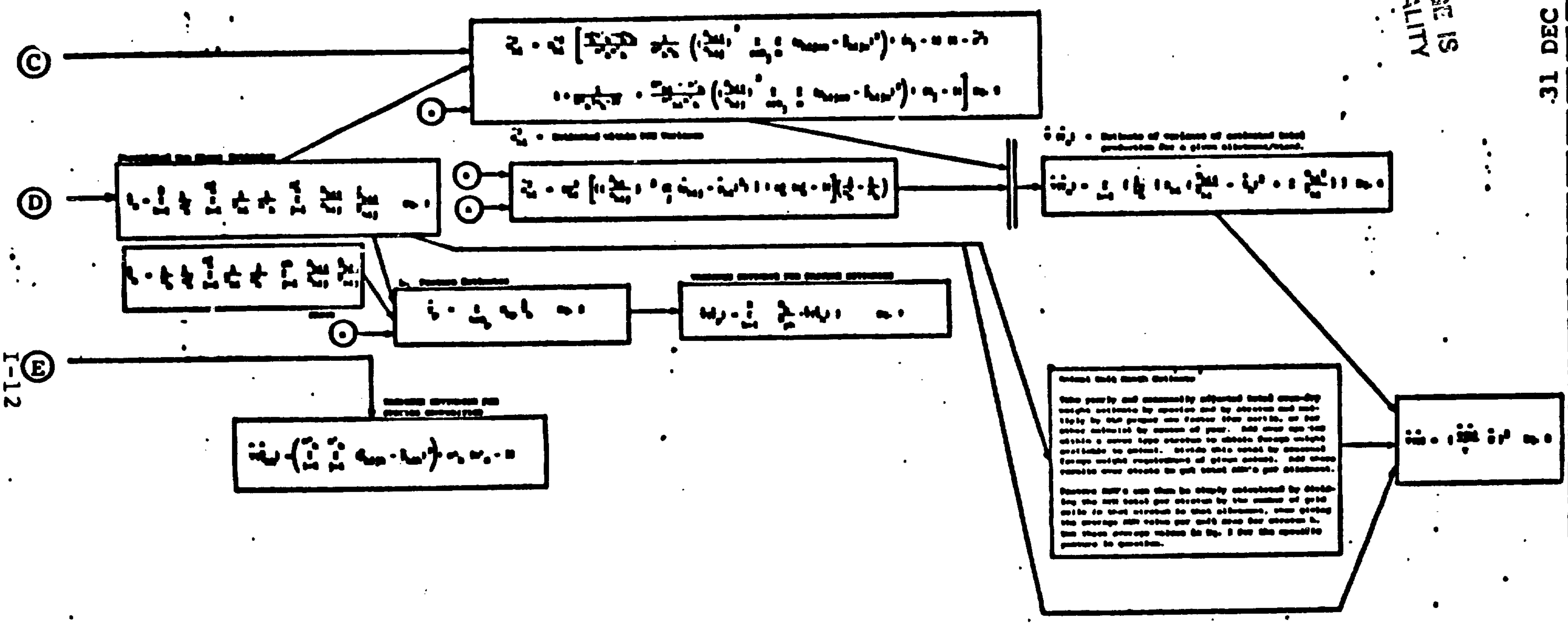

DATA ANALYSIS
AND ESTIMATION

APPENDIX II

COMPUTER MENU DESCRIPTIONS
LEVEL III FRAMEWORK CLASSIFICATION

This appendix contains selected examples of the computer class menu descriptions. See Volume II, Appendix 2-G for the complete set.

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NASA/BLM APT PHASE II

ARIZONA CLASSIFICATION VEGETATION/TERRAIN MENU DESCRIPTION

Summary Class: 3 No. of Photo Samples: 1,222 % of Total: 58

Name: Pinyon-Juniper Woodland No. of Acres: 1,056,976 No. of Hectares: ______

Spectral Classes: 33,35,41-43,46-47, 52-53,55-59,61-63,66,83-85 % of Area: .41

I. VEGETATION

(% Cover by Species)

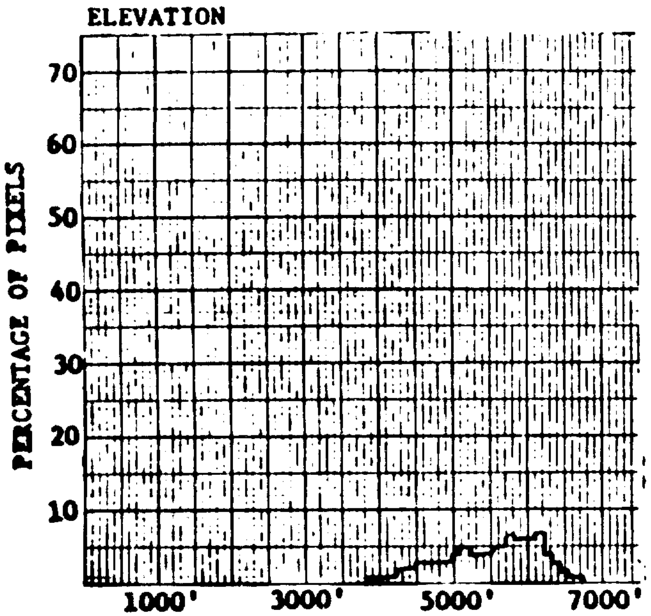
A. Trees	Mean	Std.Err.	B. Shrubs--Desert	Mean	Std.Err.
Ponderosa Pine	1.0	.1	Creosote		
Pinyon Pine	6.5	.3	Bursage		
Juniper	17.8	.4	Blackbrush	.1	.0
Other Tree	1.5	.1	Big Sagebrush	7.0	.3
			Other Shrub	2.1	.1

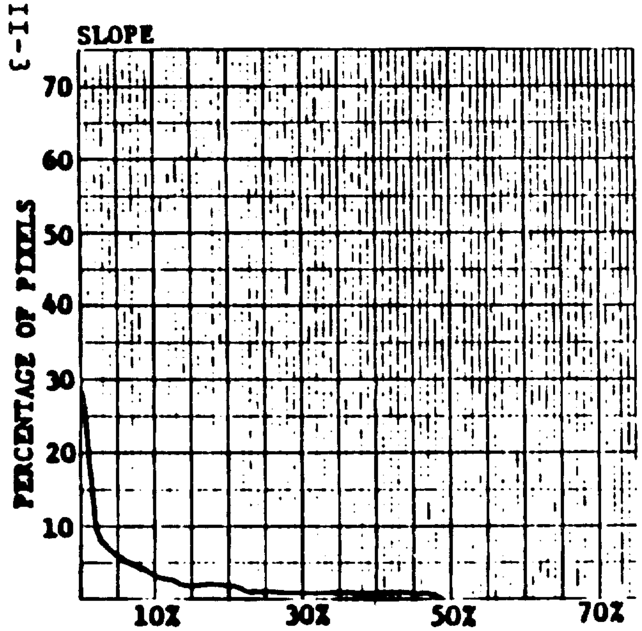
C. Shrubs--Mountain	Mean	Std.Err.	D. Riparian Woodland	Mean	Std.Err.
Gambel's Oak	3.2	.3	Cottonwood		
Turbinella Oak	1.6	.2	Willow		
Other Shrub	7.0	.4	Other Shrub		

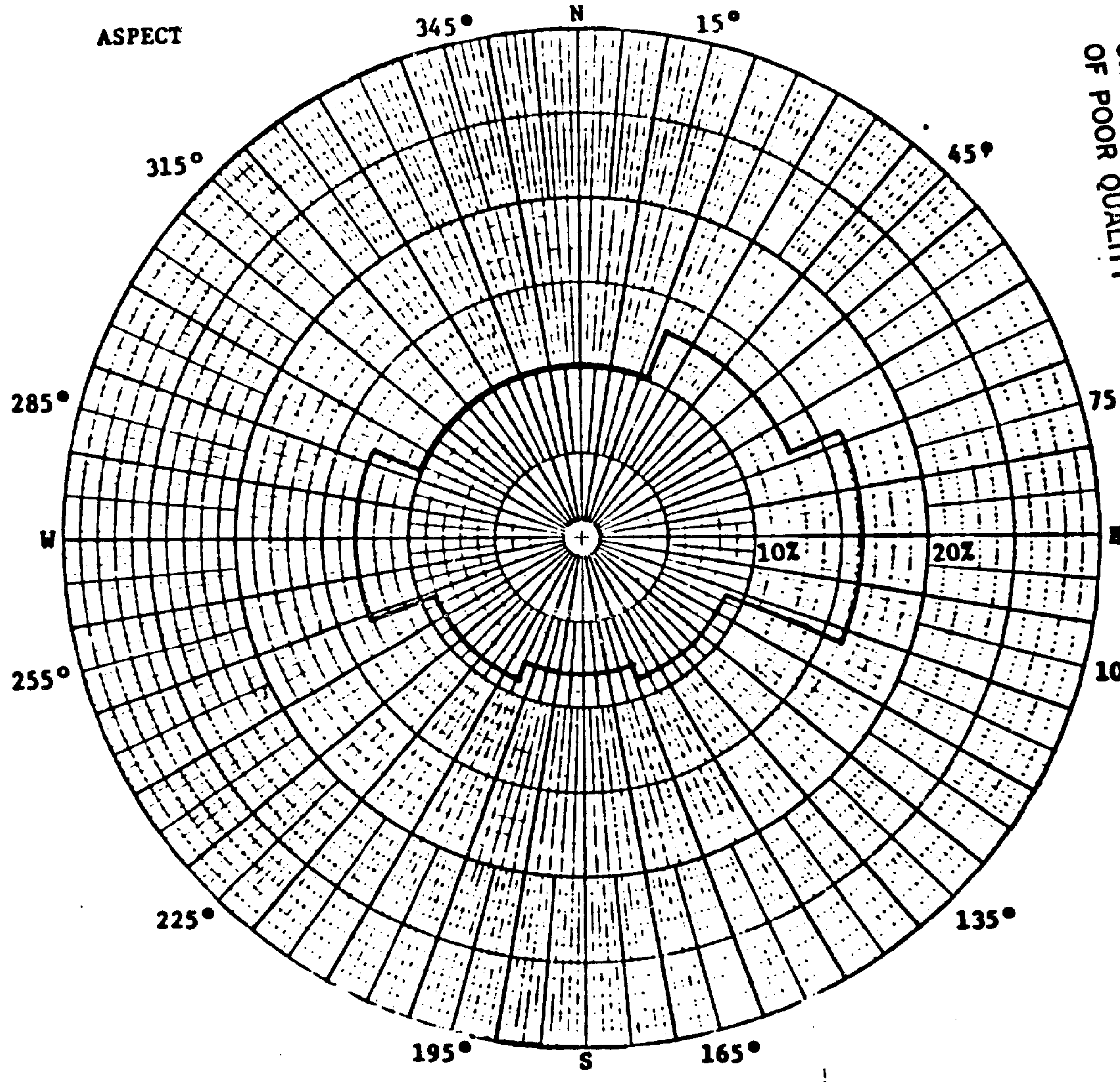
E. Grasses	Mean	Std.Err.	F. Cactus	Mean	Std.Err.
Perennials	.3	.1	Yucca	.1	0
Annuals	2.7	.3	Other Cactus		

G. Non-Vegetation	Mean	Std.Err.
Barren (Rocky)	19.7	.7
Barren (Sandy)	29.1	.8
Water		
Shadow	.4	.1

COMPUTER CLASS 3 (Pinyon Juniper Woodland) GEOBLOCK Arizona







11 % HAS NO ASPECT (FLAT)

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NASA/BLM APT PHASE II

ARIZONA CLASSIFICATION VEGETATION/TERRAIN MENU DESCRIPTION

Summary Class: 6 No. of Photo Samples: 535 % of Total: 25

Name: Great Basin Sagebrush No. of Acres: 904,389 No. of Hectares: 361,756

Spectral Classes: 11,28-30,32,34,38, 40,44,48-50,54,101-103,105-106,108,110,112,115-117 % of Area: ______

I. VEGETATION

(% Cover by Species)

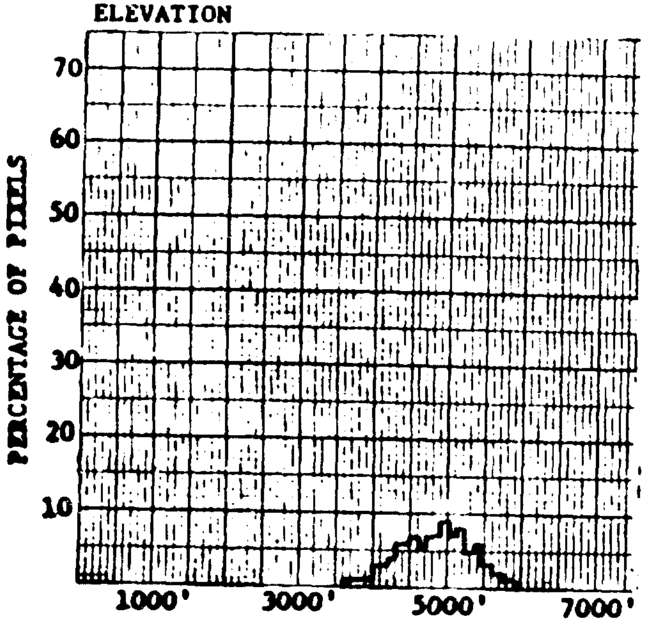
A. Trees	Mean	Std.Err.	B. Shrubs--Desert	Mean	Std.Err.
Ponderosa Pine			Creosote	.1	0
Pinyon Pine	.2	0	Bursage	.3	.1
Juniper	1.9	.2	Blackbrush	.4	.2
Other Tree			Big Sagebrush	12.3	.7
			Other Shrub	8.7	.4

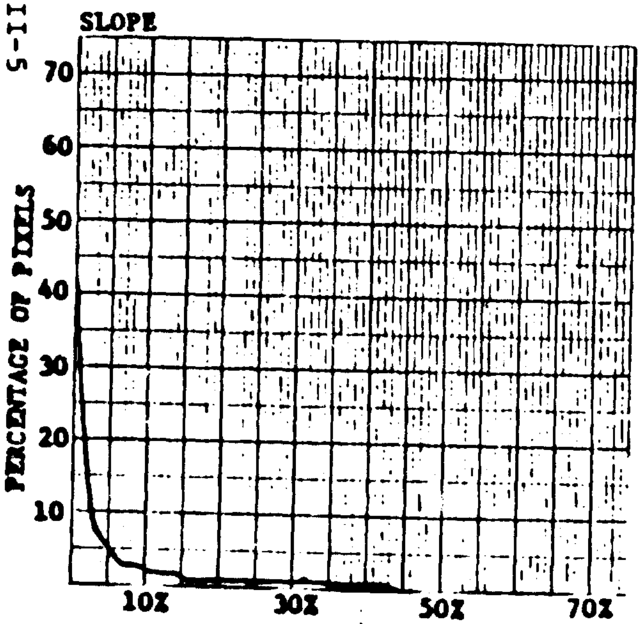
C. Shrubs--Mountain	Mean	Std.Err.	D. Riparian Woodland	Mean	Std.Err.
Gambel's Oak			Cottonwood		
Turbinella Oak	.2	.1	Willow		
Other Shrub	.8	.2	Other Shrub		

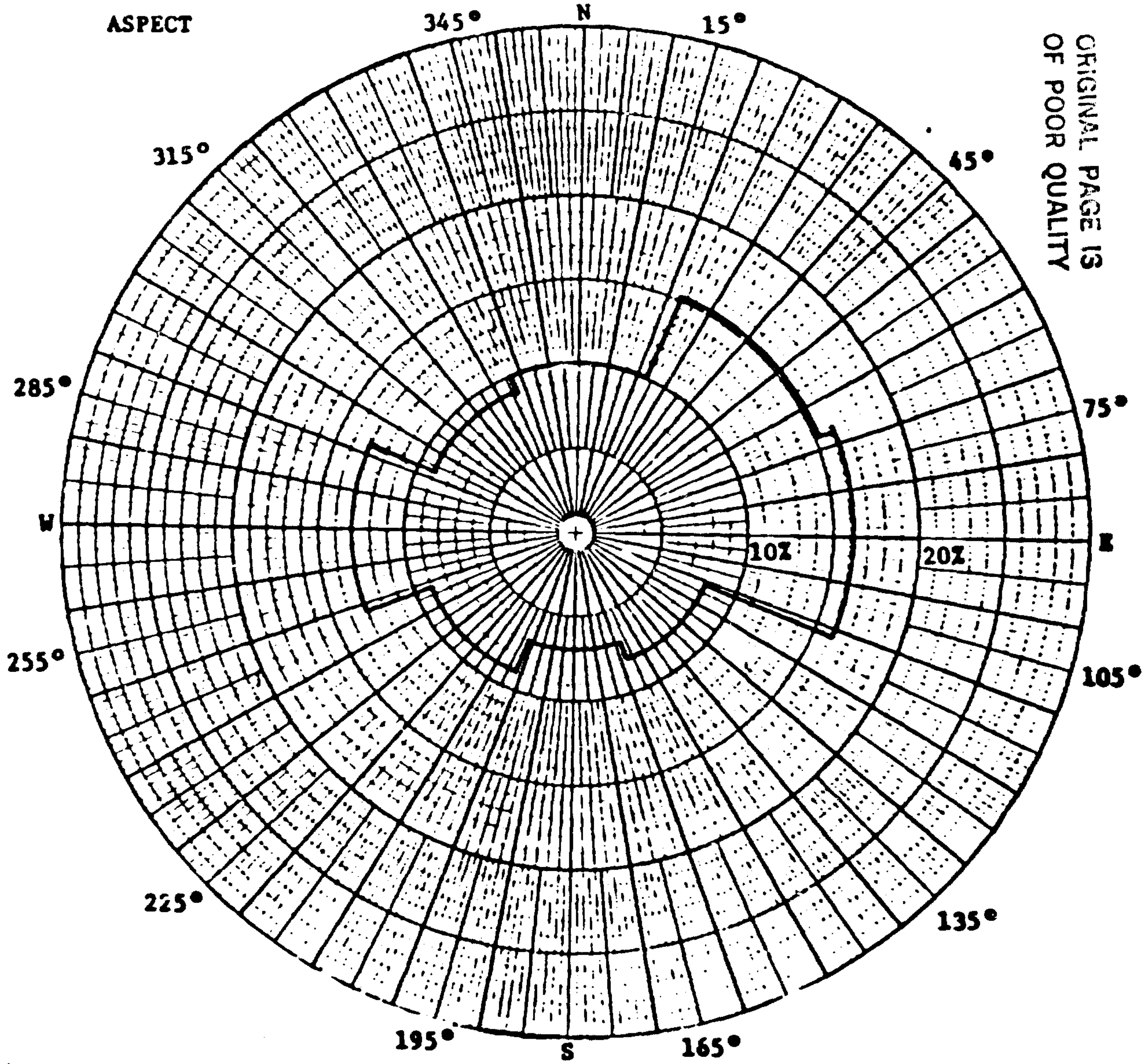
E. Grasses	Mean	Std.Err.	F. Cactus	Mean	Std.Err.
Perennials	3.2	.5	Yucca	1.5	.1
Annuals	14.9	1.0	Other Cactus	.3	.1

G. Non-Vegetation	Mean	Std.Err.
Barren (Rocky)	27.2	1.4
Barren (Sandy)	26.5	1.2
Water		
Shadow	1.4	.5

COMPUTER CLASS 6 (Great Basin Sagebrush) GEOBLOCK Arizona







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APPENDIX III

RESULTS OF RANGE PRODUCTIVITY ESTIMATION

The primary estimates of palatable cattle forage are in Table 1 for Landsat strata and Table 2 for allotment and pasture. These are the amounts available regardless of utilization. The secondary estimates, the current amounts regardless of availablility are in Table 3 for Landsat strata and Table 4 for allotment and pasture. The Landsat strata listed are the summary categories used in sampling and estimation. Results are tabulated in both pounds per acre and kilograms per hectare. The paired values in parentheses are 80% confidence intervals based on the estimated standard errors. To check the precision requirement for the primary results, it is seen that one-half the length of the confidence interval across all strata is (16.7 - 10.6)/2 = 3.05 lb/acre, which is 22% of the estimate of 13.66 lb/acre. For the secondary estimates, the result is 23%. So the precision requirement was not quite met, although it was fairly close.

The classification results combined into the 27 summary classes and the overlayed allotment and pasture boundaries provide a detailed cover type map illustrating the locations of the various range strata.

Table 1.

RANGE FORAGE ESTIMATES BY LANDSAT STRATA

PALATABLE SPECIES ONLY ____ AMOUNTS AVILABLE AND PROJECTED FOR FULL UTILIZATION

LANDSAT STRATUM	AREA			FORAGE PER UNIT AREA			
	ACRES	HECTARES	% OF TOTAL	LB/ACRE	80% CONFIDENCE INTERVAL	KG/ HECTARE	80% CONFIDENCE INTERVAL
Creosote-Bursage (rocky)	90,558	36,648	17.0	2.0	(0.8, 3.1)	2.2	(0.9. 3.5)
Creosote-Bursage (sandy)	25,742	10,418	4.8	0.7	(0.3, 1.1)	0.8	(0.3, 1.2)
Creosote-Pure	17,608	7,126	3.3	0	(0, 0)	0	(0, 0)
Upland Desert Shrub-Creosote	174	70	0.03	0	(1)	0	(1)
Blackbrush	6,384	2,584	1.2	3.2	(0.5, 5.9)	3.6	(0.5, 6.6)
Mixed Desert Shrub	17,980	7,276	3.4	2.4	(0, 5.4)	2.7	(0, 6.1)
Riparian Woodland	271	110	0.1	--	--	--	--
Shrub-Grass	5,986	2,422	1.1	37.4	(0, 118.6)	41.9	(0, 132.9)
Grassland-Shrub-Sage	86,372	34,954	16.2	20.9	(7.8, 33.9)	23.4	(8.8. 38.0)
Snakeweed-Grass-Saltshrub	39,990	16,184	7.5	24.1	(8.4, 39.8)	27.0	(9.4, 44.6)
Sage-Mixed Shrub	33,349	13,496	6.3	10.3	(6.8, 13.8)	11.6	(7.6, 15.5)

(1) INSUFFICIENT SAMPLES

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RANGE FORAGE ESTIMATES BY LANDSAT STRATA

PALATABLE SPECIES ONLY _____ AMOUNTS AVAILABLE AND PROJECTED FOR FULL UTILIZATION

LANDSAT STRATUM	AREA			FORAGE PER UNIT AREA			
	ACRES	HECTARES	% OF TOTAL	LB/ACRE	80% CONFIDENCE INTERVAL	KG/ HECTARE	80% CONFIDENCE INTERVAL
Pinyon-Juniper-Sage	51,366	20,787	9.7	14.9	(6.3, 23.6)	16.7	(7.0, 26.4)
Pinyon-Juniper-Shrub	66,634	26,966	12.5	21.1	(14.8, 27.3)	23.6	(16.6. 30.6)
Pinyon-Juniper	54,955	22,240	10.3	14.2	(0.4, 27.9	15.9	(0.5, 31.3)
Mountain Shrub-Chaparral	5,598	2,265	1.1	0.6	(1)	0.7	(1)
Agriculture	363	147	0.1	--	--	--	--
Ponderosa Pine-Oak	162	66	0.03	--	--	--	--
Ponderosa Pine-Mix	3,082	1,247	0.6	--	--	--	--
Ponderosa Pine	87	35	0.02	--	--	--	--
Shadow	2,522	1,021	0.5	23.4	(1)	26.2	(1)
Water	162	66	0.03	--	--	--	--
Bare	1,777	719	0.3	94.6	(1)	106.1	(1)

(1) INSUFFICIENT SAMPLES

RANGE FORAGE ESTIMATES BY LANDSAT STRATA

PALATABLE SPECIES ONLY _____ AMOUNTS AVAILABLE AND PROJECTEF FOR FULL UTILIZATION

LANDSAT STRATUM	AREA			FORAGE PER UNIT AREA			
	ACRES	HECTARES	% OF TOTAL	LB/ACRE	80% CONFIDENCE INTERVAL	KG/HECTARE	80% CONFIDENCE INTERVAL
Upland Desert Shrub-Blackbrush	20,835	8,432	3.9	20.8	(3.3, 38.3)	23.3	(3.7, 42.9)
TOTAL	531,957	215,276	100.0	13.66	(10.6, 16.7)	15.31	(11.9, 18.8)

(1) INSUFFICIENT SAMPLES

Table 2.

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - AMOUNTS AVAILABLE AND PROJECTED FOR FULL UTILIZATION

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
JUMP CANYON (4801)	48	12,828	5,191	2.4	17.0		19.1	
	49	4,819	1,950	0.9	18.5		20.7	
	50	10,149	4,107	1.9	18.0		20.2	
	TOTAL	27,796	11,248	5.2	17.7		19.8	
WHITEROCK/SOAPSTONE (4804)	33	6,377	2,581	1.2	18.5		20.7	
	34	7,564	3,061	1.4	18.1		20.2	
	35	4,745	1,920	0.9	17.8		20.0	
	TOTAL	18,686	7,562	3.5	18.2		20.3	
MAINSTREET (4805)	14	3,917	1,585	0.7	21.2		23.7	
	15	3,276	1,326	0.6	23.7		26.6	
	16	7,249	2,934	1.4	20.8		23.3	
	17	9,927	4,017	1.9	21.3		23.9	

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - AMOUNTS AVAILABLE AND PROJECTED FOR FULL UTILIZATION

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
MAINSTREET (4805)	18	[illegible]	[illegible]	0.2	21.9		24.6	
	19	5,319	2,152	1.0	19.3		21.7	
	20	4,389	1,776	0.8	19.7		22.1	
	21	6,905	2,794	1.3	18.8		21.1	
	22	11,876	4,806	2.2	19.4		21.7	
	23	693	280	0.1	18.8		21.1	
	24	6,936	2,807	1.3	18.4		20.6	
	25	16,573	6,707	3.1	18.4		20.6	
	51	14,467	5,854	2.7	18.5		20.7	
	52	14,516	5,874	2.7	18.4		20.6	
	53	1,949	789	0.4	17.8		19.9	
	TOTAL	108,881	44,063	20.5	19.4		21.7	

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - AMOUNTS AVAILABLE AND PROJECTED FOR FULL UTILIZATION

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
WOLFHOLE CANYON (4811)	27	13,764	5,570	2.6	13.5		15.1	
	28	4,744	1,920	0.9	5.0		5.7	
	29	7,033	2,846	1.3	19.2		21.5	
	TOTAL	25,541	10,336	4.8	13.5		15.1	
LITTLEFIELD COMM. (4827)	44	56,465	22,850	10.6	7.8		8.7	
	45	12,712	5,144	2.4	18.4		20.6	
	46	4,555	1,843	0.9	13.5		15.2	
	47	4,620	1,870	0.9	14.1		15.9	
	TOTAL	78,352	31,708	14.7	10.2		11.5	
PARASHAUNT (4829)	55	14,543	5,886	2.7	18.2		20.4	
	56	1,447	586	0.3	18.2		20.4	
	57	9,435	3,818	1.8	18.0		20.1	

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RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - AMOUNTS AVAILABLE AND PROJECTED FOR FULL UTILIZATION

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
PARASHAUNT (4829)	58	3,577	1,448	0.7	18.3		20.5	
	59	1,268	513	0.2	17.1		19.2	
	60	1,890	765	0.4	16.6		18.6	
	61	3,253	1,316	0.6	17.4		19.5	
	62	13,365	5,408	2.5	16.9		19.0	
	63	9,545	3,863	1.8	15.6		17.5	
	64	8,892	3,598	1.7	15.8		17.8	
	65	628	254	0.1	15.8		17.8	
	66	294	119	0.1	17.5		19.6	
	67	7,468	3,022	1.4	16.0		17.9	
	TOTAL	75,607	30,597	14.2	17.0		19.1	

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - AMOUNTS AVAILABLE AND PROJECTED FOR FULL UTILIZATION

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
LOWER HURRICAINE (4837)	1	8,490	3,436	1.6	11.6		13.0	
	2	5,918	2,395	1.1	11.8		13.2	
	3	6,027	2,439	1.1	11.7		13.2	
	4	1,718	695	0.3	13.6		15.3	
	5	4,245	1,718	0.8	15.7		17.6	
	6	4,796	1,941	0.9	20.7		23.2	
	7	4,810	1,946	0.9	18.0		20.2	
	8	93	38	0.02	26.6		29.8	
	9	5,086	2,058	1.0	19.2		21.5	
	10	4,278	1,731	0.8	18.9		21.2	
	11	416	168	0.1	19.6		21.9	
	TOTAL	45,876	18,566	8.6	15.3		17.2	

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - AMOUNTS AVAILABLE AND PROJECTED FOR FULL UTILIZATION

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
BLACKROCK (4841)	37	8,052	3,258	1.5	1.9		2.2	
	38	4,773	1,932	0.9	7.0		7.9	
	39	10,814	4,376	2.0	17.3		19.4	
	40	2,600	1,052	0.5	17.2		19.3	
	41	4,420	1,789	0.8	15.7		17.6	
	42	3,842	1,555	0.7	17.7		19.8	
	43	2,821	1,142	0.5	16.8		18.8	
	TOTAL	37,323	15,104	7.0	12.4		13.8	
BLACKWILLOW/TASSI (4861)	TOTAL (64)	101,198	40,954	19.0	4.6		5.1	
TOQUER TANK (4861)	12	5,958	2,411	1.1	21.0		23.6	
	13	6,740	2,727	1.3	20.6		23.1	
	TOTAL	12,698	5,138	2.4	20.8		23.3	

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RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - AMOUNTS AVAILABLE AND PROJECTED FOR FULL UTILIZATION

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
TOTAL	TOTAL	531,957	215,276	100	13.7		15.3	

Table 3.

RANGE FORAGE ESTIMATES BY LANDSAT STRATA

PALATABLE SPECIES ONLY _____ CURRENT AMOUNTS AVAILABLE OR UNAVAILABLE

LANDSAT STRATUM	AREA			FORAGE PER UNIT AREA			
	ACRES	HECTARES	% OF TOTAL	LB/ACRE	80% CONFIDENCE INTERVAL	KG/ HECTARE	80% CONFIDENCE INTERVAL
Creosote-Bursage (rocky)	90,558	36,648	17.0	2.5	(0.8, 4.1)	2.8	(0.9, 4.6)
Creosote-Bursage (sandy)	25,742	10,418	4.8	0.7	(0.2, 1.2)	0.7	(0.2, 1.3)
Creosote-Pure	17,608	7,126	3.3	0	(0, 0)	0	(0, 0)
Upland Desert Shrub-Creosote	174	70	0.03	0	(1)	0	(1)
Blackbrush	6,384	2,584	1.2	3.5	(0.4, 6.6)	4.0	(0.5, 7.4)
Mixed Desert Shrub	17,980	7,276	3.4	2.4	(0, 5.4)	2.7	(0, 6.1)
Riparian Woodland	271	110	0.1	--	--	--	--
Shrub-Grass	5,986	2,422	1.1	34.9	(0, 115.0)	39.1	(0, 128.8)
Grassland-Shrub-Sage	86,372	34,954	16.2	19.9	(6.7, 33.0)	22.2	(7.5, 36.9)
Snakeweed-Grass-Saltshrub	39,990	16,184	7.5	22.5	(6.7, 38.2)	25.2	(7.6, 42.7)
Sage-Mixed Shrub	33,349	13,496	6.3	10.5	(6.9, 14.0)	11.7	(7.7, 15.7)

(1) INSUFFICIENT SAMPLES

Page 1 of 3

RANGE FORAGE ESTIMATES BY LANDSAT STRATA

PALATABLE SPECIES ONLY _____ CURRENT AMOUNTS AVAILABLE OR UNAVAILABLE

LANDSAT STRATUM	AREA			FORAGE PER UNIT AREA			
	ACRES	HECTARES	% OF TOTAL	LB/ACRE	80% CONFIDENCE INTERVAL	KG/ HECTARE	80% CONFIDENCE INTERVAL
Pinyon-Juniper-Sage	51,366	20,787	9.7	15.7	(6.1, 25.2)	17.5	(6.9, 28.2)
Pinyon-Juniper-Shrub	66,634	26,966	12.5	27.1	(19.5, 34.6)	30.3	(21.8, 38.8)
Pinyon-Juniper	54,955	22,240	10.3	13.9	(0, 27.9)	15.5	(0, 31.2)
Mountain Shrub-Chaparral	5,598	2,265	1.1	8.4	(1)	9.4	(1)
Agriculture	363	147	0.1	--	--	--	--
Ponderosa Pine-Oak	162	66	0.03	--	--	--	--
Ponderosa Pine-Mix	3,082	1,247	0.6	--	--	--	--
Ponderosa Pine	87	35	0.02	--	--	--	--
Shadow	2,522	1,021	0.5	29.6	(1)	33.2	(1)
Water	162	66	0.03	--	--	--	--
Bare	1,777	719	0.3	93.0	(1)	104.2	(1)

(1) INSUFFICIENT SAMPLES

RANGE FORAGE ESTIMATES BY LANDSAT STRATA

PALATABLE SPECIES ONLY _____ CURRENT AMOUNTS AVAILABLE OR UNAVAILABLE

LANDSAT STRATUM	AREA			FORAGE PER UNIT AREA			
	ACRES	HECTARES	% OF TOTAL	LB/ACRE	80% CONFIDENCE INTERVAL	KG/HECTARE	80% CONFIDENCE INTERVAL
Upland Desert Shrub-Blackbrush	20,835	8,432	3.9	21.8	(3.3, 40.3)	24.4	(3.6,45.2)
TOTAL	531,957	215,276	100.0	14.38	(11.1, 17.6)	16.10	(12.5, 1[illegible].8)

(1) INSUFFICIENT SAMPLES

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Table 4.

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - CURRENT AMOUNTS AVAILABLE OR UNAVAILABLE

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
JUMP CANYON (4801)	48	12,828	5,191	2.4	18.5		20.7	
	49	4,819	1,950	0.9	19.9		22.3	
	50	10,149	4,107	1.9	20.1		22.5	
	TOTAL	27,796	11,248	5.2	19.3		21.7	
WHITEROCK/SOAPSTONE (4804)	33	6,377	2,581	1.2	20.4		22.9	
	34	7,564	3,061	1.4	20.3		22.7	
	35	4,745	1,920	0.9	19.6		21.9	
	TOTAL	18,686	7,562	3.5	20.2		22.6	
MAINSTREET (4805)	14	3,917	1,585	0.7	20.0		22.4	
	15	3,276	1,326	0.6	22.2		24.9	
	16	7,249	2,934	1.4	19.7		22.1	
	17	9,927	4,017	1.9	20.2		22.6	

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - CURRENT AMOUNTS AVAILABLE OR UNAVAILABLE

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/HECTARE	
MAINSTREET (4805)	18	890	360	0.2	21.0		23.5	
	19	5,319	2,152	1.0	18.5		20.7	
	20	4,389	1,776	0.8	18.9		21.1	
	21	6,905	2,794	1.3	18.4		20.6	
	22	11,876	4,806	2.2	18.6		20.8	
	23	693	280	0.1	18.2		20.4	
	24	6,936	2,807	1.3	17.9		20.1	
	25	16,573	6,707	3.1	17.9		20.1	
	51	14,447	[illegible]	2.7	[illegible]		[illegible]	
	52	14,516	5,874	2.7	18.7		21.0	
	53	1,949	789	0.4	17.2		19.3	
	TOTAL	108,881	44,063	20.5	19.1		21.4	

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RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - CURRENT AMOUNTS AVAILABLE OR UNAVAILABLE

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
WOLFHOLE CANYON (4811)	27	13,764	5,570	2.6	13.6		15.3	
	28	4,744	1,920	0.9	5.3		6.0	
	29	7,033	2,846	1.3	19.9		22.3	
	TOTAL	25,541	10,336	4.8	13.8		15.5	
LITTLEFIELD COMM. (4827)	44	56,465	22,850	10.6	8.9		9.9	
	45	12,712	5,144	2.4	20.2		22.7	
	46	4,555	1,843	0.9	17.6		19.7	
	47	4,620	1,870	0.9	18.6		20.9	
	TOTAL	78,352	31,708	14.7	11.8		13.2	
PARASHAUNT (4829)	55	14,543	5,886	2.7	19.2		21.5	
	56	1,447	586	0.3	19.2		21.5	
	57	9,435	3,818	1.8	21.0		23.5	

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - CURRENT AMOUNTS AVAILABLE OR UNAVAILABLE

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
PARASHAUNT (482[illegible])	58	3,577	1,448	0.7	21.4		24.0	
	59	1,268	513	0.2	19.6		21.9	
	60	1,890	765	0.4	18.7		20.9	
	61	3,253	1,316	0.6	20.3		22.7	
	62	13,365	5,408	2.5	19.2		21.5	
	63	9,545	3,863	1.8	16.7		18.7	
	64	8,892	3,598	1.7	17.1		19.1	
	65	628	254	0.1	17.3		19.3	
	66	294	119	0.1	20.2		22.6	
	67	7,468	3,022	1.4	17.3		19.4	
	TOTAL	75,607	30,597	14.2	18.8		21.1	
LOWER HURRICANE (4837)	1	8,490	3,436	1.6	11.8		13.2	

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - CURRENT AMOUNTS AVAILABLE OR UNAVAILABLE

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
LOWER HURRICAINE (4837)	2	5,918	2,395	1.1	12.2		13.6	
	3	6,027	2,439	1.1	11.7		13.1	
	4	1,718	695	0.3	13.2		14.8	
	5	4,245	1,718	0.8	15.0		16.8	
	6	4,796	1,941	0.9	19.6		22.0	
	7	4,810	1,946	0.9	17.3		19.3	
	8	93	38	0.02	25.0		27.9	
	9	5,086	2,058	1.0	18.2		20.4	
	10	4,278	1,731	0.8	18.1		20.2	
	11	416	168	0.1	18.5		20.8	
	TOTAL	45,876	18,566	8.6	15.0		16.8	
BLACKROCK (4841)	37	8,052	3,258	1.5	2.2		2.4	

RANGE FORAGE ESTIMATES BY PASTURE

PALATABLE SPECIES ONLY - CURRENT AMOUNTS AVAILABLE OR UNAVAILABLE

ALLOTMENT	PASTURE	AREA			FORAGE PER UNIT AREA			
		ACRES	HECTARES	% OF TOTAL	LB/ACRE		KG/ HECTARE	
BLACKROCK (4841)	38	4,773	1,932	0.9	7.5		8.4	
	39	10,814	4,376	2.0	19.3		21.6	
	40	2,600	1,052	0.5	19.7		22.1	
	41	4,420	1,789	0.8	17.0		19.1	
	42	3,842	1,555	0.7	21.5		24.1	
	43	2,821	1,142	0.5	19.1		21.4	
	TOTAL	37,323	15,104	7.0	13.9		15.6	
BLACKWILLOW/TASSI (4851)	TOTAL (54)	101,198	40,954	19.0	5.0		5.6	
TOQUER TANK (4861)	12	5,958	2,411	1.1	20.0		22.4	
	13	6,740	2,727	1.3	19.7		22.0	
	TOTAL	12,698	5,138	2.4	19.8		22.2	
TOTAL	TOTAL	531,957	215,276	100	14.4		16.1	

APPENDIX IV

RESULTS OF WOODLAND PRODUCTIVITY ESTIMATION

The juniper estimates by allotment are in Table 1 for standard measures and Table 2 for metric measures. The corresponding pinyon pine estimates are in Tables 3 and 4. In each table the "Total Area" is for the entire area of interest while the "Sampling Frame Area" is for BLM land only since other ownerships were excluded from the sampling. The volumes per unit area are obtained by dividing the total volumes by the Sampling Frame Area. The paired values below the volume estimates are 80% confidence intervals. These are estimated from the standard error of the estimate and the expected deviation for 80% confidence based on a sampled Gaussian distribution. To check the precision requirement for juniper, it is seen on Table 1 that one-half the length of the confidence interval across all allotments is (185.2-142.3)/2 = 21.4, which is only 13% of the estimate of 163.7 cubic feet per acre. Therefore, this precision requirement was met. However, for pinyon pine in Table 3, (37.0-19.0)/2 = 9.0 which is 32% of the 28.0 estimate. This shows that the precision requirement was not met for pinyon pine. The column labeled "Relative Standard Error" contains the standard error divided by the estimate. The other columns in the tables are for average size (diameter) and average age in years, along with associated 80% confidence intervals.

Table 1.

JUNIPER ESTIMATES

ALLOTMENT	TOTAL AREA IN ACRES	SAMPLING FRAME AREA(BLM LAND) IN ACRES	TOTAL CUBIC FOOT VOLUME IN THOUSANDS	CUBIC FOOT VOLUME PER ACRE	STANDARD ERROR	RELATIVE STANDARD ERROR	AVERAGE SIZE IN FEET	AVERAGE AGE IN YEARS
WOLFHOLE	13,308	12,418	2,215 (1,479;2,951)	178.4 (119.1;237.7)	45.9	.26	14.0 (8.9;19.1)	126 (41;211)
WOLFHOLE MTN.	14,727	14,721	2,770 (1,756;3,785)	188.2 (119.3;257.1)	53.5	.28	15.6 (9.8;21.5)	101 (60;143)
LACKROCK	37,323	32,814	4,831 (3,119;6,543)	147.2 (95.1;199.4)	40.6	.28	12.4 (6.6;18.2)	183 (137;228)
TOTALS	65,358	59,953	9,817 (8,533;11,101)	163.7 (142.3;185.2)	16.7	.10	13.6 (7.8;19.4)	137 (67;206)

ESTIMATES APPLY TO BLM LAND ONLY.

NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS.

Table 2.

JUNIPER ESTIMATES IN METRIC UNITS

ALLOTMENT	TOTAL AREA IN HECTARES	SAMPLING FRAME AREA (BLM LAND) IN HECTARES	TOTAL CUBIC METER VOLUME	CUBIC METER VOLUME PER HECTARE	STANDARD ERROR	RELATIVE STANDARD ERROR	AVERAGE SIZE IN METERS	AVERAGE AGE IN YEARS
WOLFHOLE	5,386	5,026	62,729 (41,884;83,574)	12.48 (8.33;16.63)	3.21	.26	4.2 (2.7;5.8)	126 (41;211)
WOLFHOLE MTN.	5,960	5,958	78,448 (49,730;107,166)	13.17 (8.35;17.99)	3.74	.28	4.7 (3.0;6.5)	101 (60;143)
BLACKROCK	15,104	13,279	136,807 (88,325;185,289)	10.30 (6.65;13.95)	2.84	.28	3.8 (2.0;5.5)	183 (137;228)
TOTALS	26,450	24,263	277,984 (241,634;314,334)	11.46 (9.96;12.96)	1.17	.10	4.1 (2.4;5.9)	137 (67;206)

ESTIMATES APPLY TO BLM LAND ONLY.

NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS.

Table 3.

PINYON ESTIMATES

ALLOTMENT	TOTAL AREA IN ACRES	SAMPLING FRAME AREA(BLM LAND) IN ACRES	TOTAL CUBIC FOOT VOLUME IN THOUSANDS	CUBIC FOOT VOLUME PER ACRE	STANDARD ERROR	RELATIVE STANDARD ERROR	AVERAGE SIZE IN FEET	AVERAGE AGE IN YEARS
WOLFHOLE	13,308	12,418	341 (77;605)	27.5 (6.2;48.8)	16.5	.60	18.5 (11.8;25.2)	140 (68;211)
WOLFHOLE MTN.	14,727	14,/21	478 (58;898)	32.5 (4.0;61.0)	22.1	.68	14.5 (3.6;25.4)	66 (46;85)
BLACKROCK	37,323	32,814	857 (210;1,505)	26.1 (6.4;45.9)	15.4	.59	21.2 (10.2;32.2)	160 (35;285)
TOTALS	65,358	59,953	1,677 (1,137;2,216)	28.0 (19.0;37.0)	7.0	.25	18.8 (11.7;26.0)	135 (57;213)

ESTIMATES APPLY TO BLM LAND ONLY.

NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS.

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Table 4.

PINYON ESTIMATES IN METRIC UNITS

ALLOTMENT	TOTAL AREA IN HECTARES	SAMPLING FRAME AREA(BLM LAND) IN HECTARES	TOTAL CUBIC METER VOLUME	CUBIC METER VOLUME PER HECTARE	STANDARD ERROR	RELATIVE STANDARD ERROR	AVERAGE SIZE IN METERS	AVERAGE AGE IN YEARS
WOLFHOLE	5386	5026	9662 (2185;17,139)	1.92 (0.43;3.41)	1.15	.60	5.6 (3.6;7.6)	140 (68;211)
WOLFHOLE MTN.	5960	5958	13,542 (1663;25,421)	2.27 (0.28;4.27)	1.55	.68	4.4 (1.1;7.7)	66 (46;85)
BLACKROCK	15,104	13,279	24,280 (5935;42,625)	1.83 (0.45;3.21)	1.08	.59	6.4 (3.1;9.8)	160 (35;285)
TOTALS	26,450	24,263	47,483 (32,204;62,762)	1.96 (1.33;2.59)	0.491	.25	5.7 (3.6;7.9)	135 (57;213)

ESTIMATES APPLY TO BLM LAND ONLY.

NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS.

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APPENDIX V

RESULTS OF FOREST PRODUCTIVITY ESTIMATION

The estimates of Ponderosa pine board foot volume by Landsat strata are given in Table 1 for the Blackrock-Virgin Mountains Area and Table 2 for the Mt. Trumbull-Whitmore Canyon Area. The combined totals are in Table 3. In each table the "Landsat Stratum" column refers to the 27 summary classes. "Total Area in Acres" is the entire area of interest and "Sampling Frame Area in Acres" is the set of all PSU's which contain any pixels in any of the three Ponderosa pine strata. The volume estimates are in the next two columns. The values in parentheses are 80% confidence intervals. These are estimated from the standard error of the estimate and the expected deviation for an 80% confidence interval based on a sampled Gaussian distribution. To check the precision requirement it is seen that one-half the length of the confidence interval across all strata is (147-113)/2=17, which is only 13% of the estimate of 130 board feet per acre. Therefore, the precision requirement was met easily. The column labeled "Relative Standard Error" is the standard error divided by the estimate.

Table 1.

PONDEROSA PINE VOLUME ESTIMATES

AREA: A

BLACKROCK-VIRGIN MOUNTAINS

LANDSAT STRATUM	TOTAL AREA IN ACRES	SAMPLING FRAME AREA IN ACRES	TOTAL BOARD FOOT VOLUME	BOARD FOOT VOLUME PER ACRE	STANDARD ERROR	RELATIVE STANDARD ERROR	NO. OF PHOTO SAMPLES
Creosote-Bur-sage (rocky)	25,903	0	0	-	-	-	0
Creosote-Bur-sage (sandy)	24,663	0	0	-	-	-	0
Creosote-Pure	12,072	2	0	0(1)	(3)	(3)	0
Upland Desert Shrub-Creosote	423	0	0	-	-	-	0
Blackbrush	3,488	0	0	-	-	-	0
Mixed Desert Shrub	10,375	0	0	-	-	-	0
Riparian Woodland	221	72	0	0	0	-	3
Shrub-Grass	29	0	0	-	-	-	0
Grassland-Shrub	504	90	1752	19(2)	(3)	(3)	0
Snakeweed-Grass	670	4	0	0(1)	(3)	(3)	0
Sage - Mix Shrub	1,598	49	954	19(2)	(3)	(3)	0
Sage	6,792	95	0	0	(3)	(3)	1
Saltshrub	9	1	0	0(1)	(3)	(3)	0
Pinyon-Juniper-Sage	12,996	413	8042	19(2)	(3)	(3)	0

(1) NO SAMPLES, INSIGNIFICANT ACREAGE - ZERO VOLUME ASSIGNED
(2) NO SAMPLES, SIGNIFICANT ACREAGE - POOLED ESTIMATE USED FROM ALL STRATA EXCEPT 20, 21, 22
(3) NOT ESTIMABLE - INSUFFICIENT SAMPLES

OTHER NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS

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Table 1. --Continued.

PONDEROSA PINE VOLUME ESTIMATES

AREA: A

BLACKROCK-VIRGIN MOUNTAINS

LANDSAT STRATUM	TOTAL AREA IN ACRES	SAMPLING FRAME AREA IN ACRES	TOTAL BOARD FOOT VOLUME	BOARD FOOT VOLUME PER ACRE	STANDARD ERROR	RELATIVE STANDARD ERROR	NO. OF PHOTO SAMPLES
Pinyon-Juniper-Shrub	40,522	11,360	0	0	0	-	57
Pinyon-Juniper	38,608	12,307	410,723	33 (11,55)	17	.51	66
Mountain Shrub	2,917	722	0	0	(3)	(3)	2
Mixed Chaparral	3,409	2,659	84,664	32	0	0	25
Agriculture	154	0	0	-	-	-	0
Ponderosa Pine-Oak	156	156	0	0	(3)	(3)	1
Ponderosa Pine-Mix	1,948	1,948	353,163	181 (147,215)	25	.14	23
Ponderosa Pine	95	95	0	0	0	-	2
Shadow	1,942	303	5,900	19(2)	(3)	(3)	0
Water	1	0	0	-	-	-	0
Bare	101	2	0	0(1)	(3)	(3)	0
Upland Des. Shr.-Blkbrsh	13,606	107	2,083	19(2)	(3)	(3)	0
Sage-Grass	6,520	40	779	19(2)	(3)	(3)	0
TOTAL	209,723	30,425	868,060	29 (13,45)	12	.42	180

(1) NO SAMPLES, INSIGNIFICANT ACREAGE - ZERO VOLUME ASSIGNED
(2) NO SAMPLES, SIGNIFICANT ACREAGE - POOLED ESTIMATE USED FROM ALL STRATA EXCEPT 20, 21, 22
(3) NOT ESTIMABLE - INSUFFICIENT SAMPLES

OTHER NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS

Table 2.

POMDEROSA PINE VOLUME ESTIMATES

AREA: B

MT. TRUMBULL-WHITMORE CANYON

LANDSAT STRATUM	TOTAL AREA IN ACRES	SAMPLING FRAME AREA IN ACRES	TOTAL BOARD FOOT VOLUME	BOARD FOOT VOLUME PER ACRE	STANDARD ERROR	RELATIVE STANDARD ERROR	NO. OF PHOTO SAMPLES
Creosote-Bur-sage (rocky)	568	0	0	-	-	-	0
Creosote-Bur-sage (sandy)	177	0	0	-	-	-	0
Creosote-Pure	67	1	0	0(1)	(3)	(3)	0
Upland Desert Shrub-Creosote	44	0	0	-	-	-	0
Blackbrush	26	0	0	-	-	-	0
Mixed Desert Shrub	36	0	0	-	-	-	0
Riparian Woodland	20	16	0	0(1)	(3)	(3)	0
Shrub-Grass	208	0	0	-	-	-	0
Grassland-Shrub	1481	9	0	0(1)	(3)	(3)	0
Snakeweed-Grass	2221	6	0	0(1)	(3)	(3)	0
Sage - Mix Shrub	5502	30	0	0	(3)	(3)	1
Sage	17,966	149	0	0	0	-	4
Saltshrub	86	0	0	-	-	-	0
Pinyon-Juniper-Sage	20,523	683	0	0	0	-	8

(1) NO SAMPLES, INSIGNIFICANT ACREAGE - ZERO VOLUME ASSIGNED
(2) NO SAMPLES, SIGNIFICANT ACREAGE - POOLED ESTIMATE USED FROM ALL STRATA EXCEPT 20, 21, 22
(3) NOT ESTIMABLE - INSUFFICIENT SAMPLES

OTHER NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS

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Table 2. --Continued.

PONDEROSA PINE VOLUME ESTIMATES

AREA: B

MT. TRUMBULL-WHITMORE CANYON

LANDSAT STRATUM	TOTAL AREA IN ACRES	SAMPLING FRAME AREA IN ACRES	TOTAL BOARD FOOT VOLUME	BOARD FOOT VOLUME PER ACRE	STANDARD ERROR	RELATIVE STANDARD ERROR	NO. OF PHOTO SAMPLES
Pinyon-Juniper-Shrub	55,785	18,101	2,719,766	150 (78,222)	55	.37	138
Pinyon-Juniper	34,869	19,997	1,097,281	55 (24,86)	24	.43	119
Mountain Shrub	2,012	1,629	275,506	169 (0,447)	188	1.11	9
Mixed Chaparral	305	27	0	0(1)	(3)	(3)	0
Agriculture	0	0	0	-	-	-	0
Ponderosa Pine-Oak	746	746	214,110	287 (0,597)	222	.77	14
Ponderosa Pine-Mix	9,210	9,210	2,874,646	312 (180,444)	102	.33	126
Ponderosa Fine	4,460	4,460	2,309,695	518 (307,729)	162	.31	80
Shadow	704	469	263,107	561	(3)	(3)	4
Water	1	0	0	-	-	-	0
Bare	1	0	0	-	-	-	0
Upland Des. Shr.-Blkbrsh	6,457	959	0	0	0	-	7
Sage-Grass	5,153	98	10,406	107(2)	(3)	(3)	0
TOTAL	168,628	56,590	9,764,597	173 (149,197)	19	.11	510

(1) NO SAMPLES, INSIGNIFICANT ACREAGE - ZERO VOLUME ASSIGNED
(2) NO SAMPLES, SIGNIFICANT ACREAGE - POOLED ESTIMATE USED FROM ALL STRATA EXCEPT 20, 21, 22
(3) NOT ESTIMABLE - INSUFFICIENT SAMPLES

OTHER NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS

Table 3.

PONDEROSA PINE VOLUME ESTIMATES

AREA: A AND B COMBINED

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LANDSAT STRATUM	TOTAL AREA IN ACRES	SAMPLING FRAME AREA IN ACRES	TOTAL BOARD FOOT VOLUME	BOARD FOOT VOLUME PER ACRE	STANDARD ERROR	RELATIVE STANDARD ERROR	NO. OF PHOTO SAMPLES
Creosote-Bursage (rocky)	26,472	0	0	-	-	-	0
Creosote-Bursage (sandy)	24,840	0	0	-	-	-	0
Creosote-Pure	12,139	4	0	0(1)	(3)	(3)	0
Upland Desert Shrub-Creosote	467	0	0	-	-	-	0
Blackbrush	3,514	0	0	-	-	-	0
Mixed Desert Shrub	10,411	0	0	-	-	-	0
Riparian Woodland	240	88	0	0	0	-	3
Shrub-Grass	237	0	0	-	-	-	0
Grassland-Shrub	1,985	99	7,588	77(2)	(3)	(3)	0
Snakeweed-Grass	2,891	9	0	0(1)	(3)	(3)	0
Sage - Mix Shrub	7,100	78	0	0	(3)	(3)	1
Sage	24,757	244	0	0	0	-	5
Saltshrub	95	1	0	0(1)	(3)	(3)	0
Pinyon-Juniper-Sage	33,520	1097	0	0	0	-	8

(1) NO SAMPLES, INSIGNIFICANT ACREAGE - ZERO VOLUME ASSIGNED
(2) NO SAMPLES, SIGNIFICANT ACREAGE - POOLED ESTIMATE USED FROM ALL STRATA EXCEPT 20, 21, 22
(3) NOT ESTIMABLE - INSUFFICIENT SAMPLES

OTHER NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS

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Table 3. --Continued.

PONDEROSA PINE VOLUME ESTIMATES
AREA: A & B COMBINED

LANDSAT STRATUM	TOTAL AREA IN ACRES	SAMPLING FRAME AREA IN ACRES	TOTAL BOARD FOOT VOLUME	BOARD FOOT VOLUME PER ACRE	STANDARD ERROR	RELATIVE STANDARD ERROR	NO. OF PHOTO SAMPLES
Pinyon-Juniper-Shrub	96,3[illegible]	29,461	3,132,706	106 (32,180)	57	.54	195
Pinyon-Juniper	73,477	32,304	1,524,823	47 (14,90)	33	.71	185
Mountain Shrub	4,929	2,351	325,320	138 (0,411)	190	1.37	11
Mixed Chaparral	3,715	2,687	85,556	32	0	0	25
Agriculture	154	0	0	-	-	-	0
Ponderosa Pine-Oak	902	902	214,110	237 (0,558)	230	.97	15
Ponderosa Pine-Mix	11,157	11,157	3,227,809	289 (145,433)	111	.38	149
Ponderosa Pine	4,555	4,555	2,309,695	507 (290,724)	167	.33	82
Shadow	2,646	772	433,088	561	(3)	(3)	4
Water	2	0	0	-	-	-	0
Bare	103	2	0	0(1)	(3)	(3)	0
Upland Des. Shr.-Blkbrsh	20,063	1,067	0	0	0	-	7
Sage-Grass	11,673	138	10,577	77(2)	(3)	(3)	0
TOTAL	378,351	87,015	11,271,272	130 (113,147)	13	.10	690

(1) NO SAMPLES, INSIGNIFICANT ACREAGE - ZERO VOLUME ASSIGNED
(2) NO SAMPLES, SIGNIFICANT ACREAGE - POOLED ESTIMATE USED FROM ALL STRATA EXCEPT 20, 21, 22
(3) NOT ESTIMABLE - INSUFFICIENT SAMPLES

OTHER NUMBERS IN PARENTHESES ARE 80% CONFIDENCE INTERVALS